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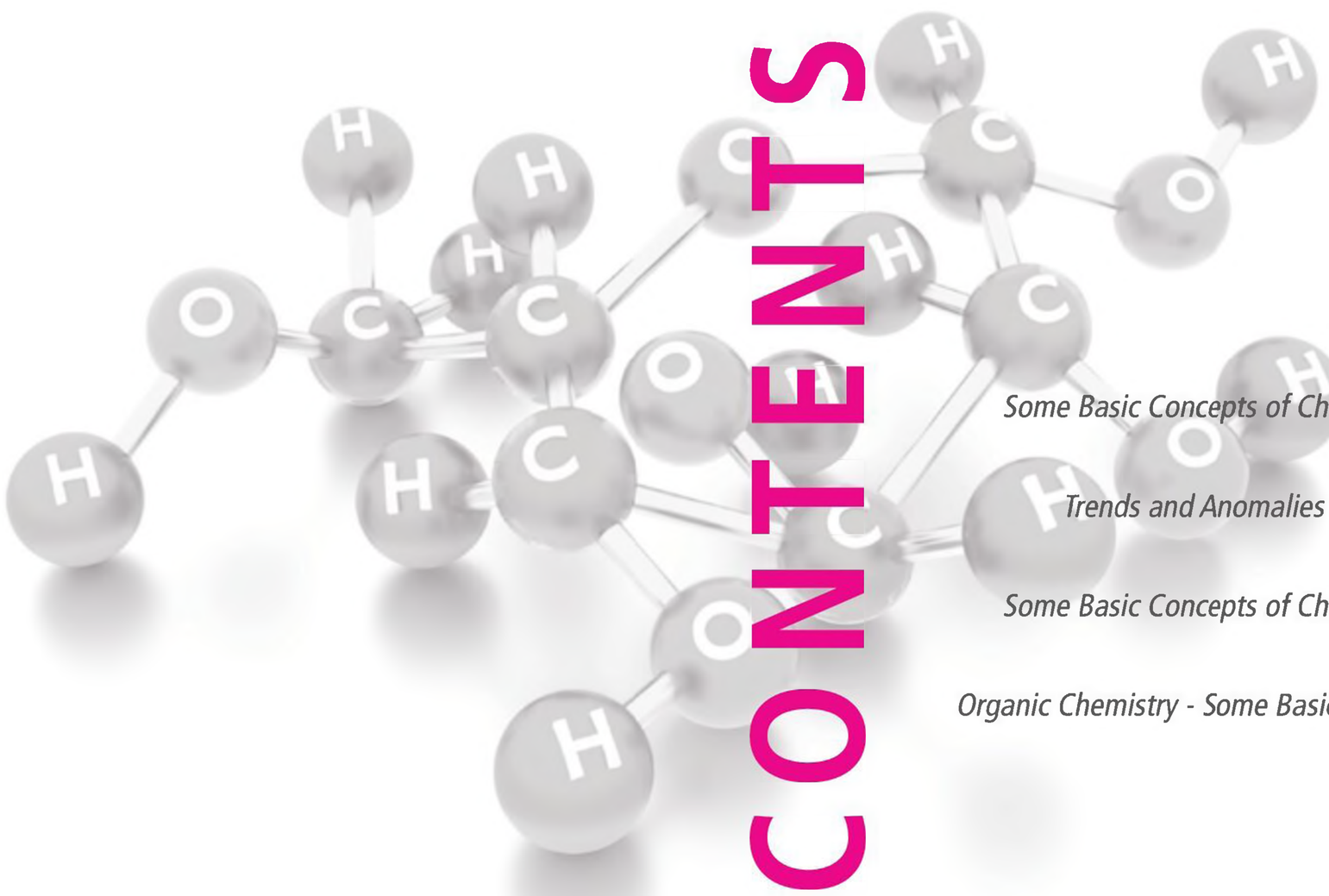

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GEAR UP for JEE MAIN 2021

Section A will be of Multiple Choice Questions (MCQs). Section B will contain questions whose answers are to be filled in as a Numerical Value. In Section B candidates have to attempt any five questions out of 10.

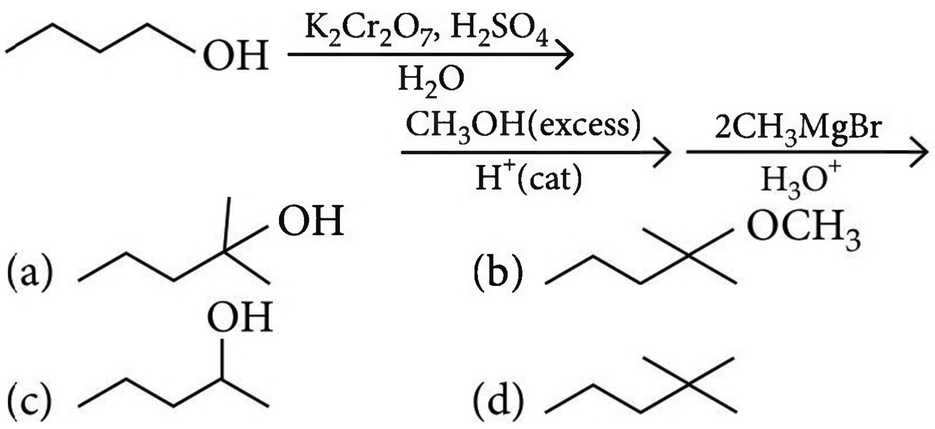
SECTION A (MULTIPLE CHOICE QUESTIONS)

1. The stability constants of the complexes formed by a metal ion (M^{2+}) with NH_3, CN^-, H_2O and *en* are of the order 10^{11}, 10^{27}, 10^{15}, and 10^{8} respectively. This shows
(a) *en* is the strongest ligand
(b) CN^- is the strongest ligand
(c) H_2O is the strongest ligand
(d) all the ligands are equally strong.

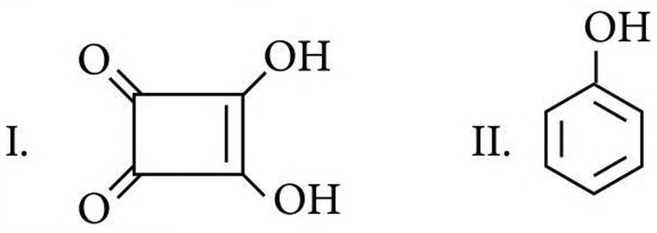
2. Although hexafluoroethane (C_2F_6, b.pt. – 79°C) and ethane (C_2H_6, b.pt. – 89°C) differ very much in their molecular weights, their boiling points differ only by 10°C. This is due to
(a) low polarizability of F
(b) nearly similar size of F and H
(c) high polarizability of F
(d) both (a) and (b)

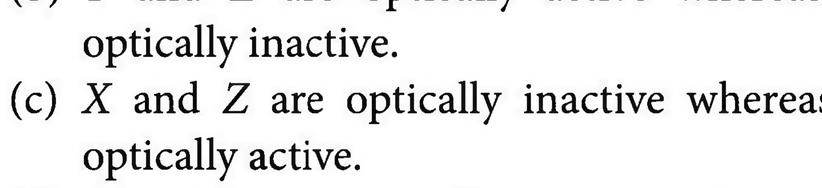
3. On heating 5×10^{-3} eq. of $CaCl_2 \cdot xH_2O$, 0.18 g of water is obtained, what is the value of x?
(a) 5 (b) 4 (c) 3 (d) 2

4. The end product of the following sequence of reactions is



5. The acid strength order of the following compounds is :





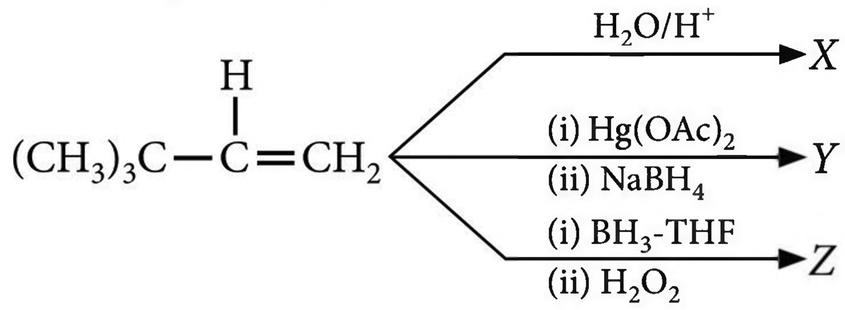
(a) I > IV > II > III (b) III > I > II > IV
(c) II > III > I > IV (d) I > III > II > IV

6. Doctors detect diabetes disease by testing the glucose in urine by
(a) Nessler's reagent (b) Fehling's solution
(c) Fenton's reagent (d) silver nitrate solution.

7. When NaCl or KCl is heated with conc. H_2SO_4 and solid $K_2Cr_2O_7$, we get
(a) chromic chloride (b) chromous chloride
(c) chromyl chloride (d) chromic sulphate.

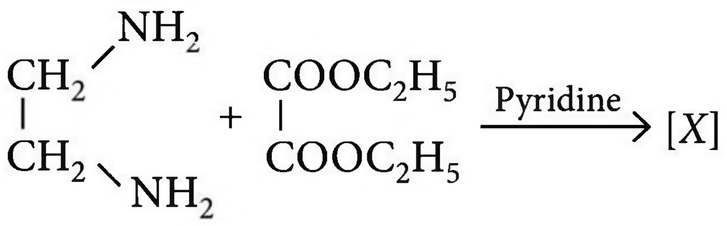
8. A metal (M) burns with dazzling brilliance in air to give a white powder. The product reacts with water to form a white precipitate and a colourless gas with a characteristic smell. The metal (M) decomposes hot water but not cold water, liberating the inflammable hydrogen gas. The metal (M) is
(a) K (b) Ca (c) Mg (d) Rb

9. The correct statement(s) about the following reaction sequence is/are

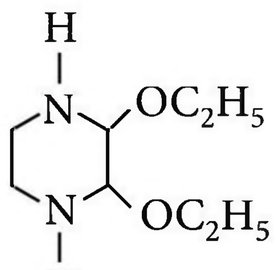


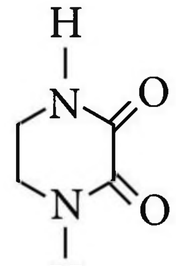
(a) X and Y are optically active whereas Z is optically inactive.
(b) Y and Z are optically active whereas X is optically inactive.
(c) X and Z are optically inactive whereas Y is optically active.
(d) Y and Z are optically inactive whereas X is optically active.

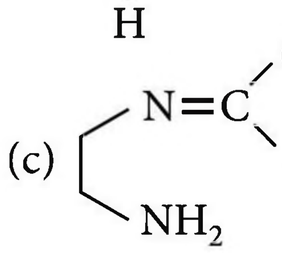
10. In the given reaction :

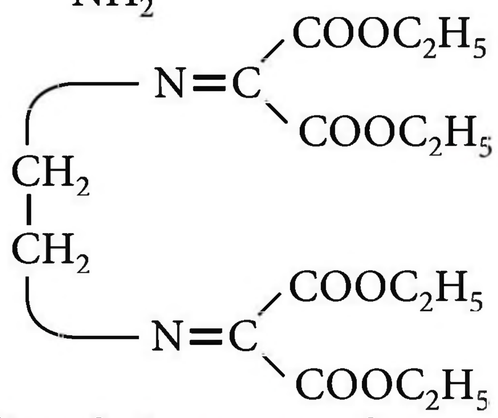


$[X]$ will be

(a) 

(b) 

(c) 

(d) 

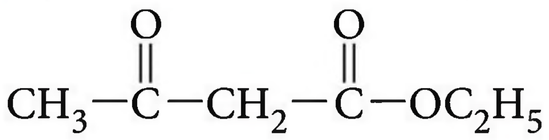
11. Sodium fusion extract of an organic compound gives blood red colour with $FeSO_4$/conc. H_2SO_4 on heating. Fresh extract of the same compound gives black precipitate when mixed with $(CH_3COO)_2Pb$ and yellow precipitate when treated with $AgNO_3$ solution. Then the organic compound may also contain

(a) N, Cl (b) N, I (c) N, S, I (d) S, I

12. Which of the following drug is tranquilizer and sedative?

(a) Sulphadiazene (b) Papaverine
(c) Equanil (d) Mescaline

13. The IUPAC name of the following compound is



(a) ethyl–3–ketobutyrate (b) ethyl-3-oxobutanoate
(c) 1-carbethoxypropanone
(d) ethyl acetoacetate.

14. The electronegativity difference between N and F is greater than N and H, yet the dipole moment of NH_3(1.5 D) is greater than that of NF_3(0.2 D). This is because

(a) in NH_3 as well as NF_3, the atomic dipole and bond dipole are in opposite direction
(b) in NH_3, the atomic dipole and bond dipole are in the opposite direction, whereas in NF_3 these are in same direction
(c) in NH_3 as well as in NF_3 the atomic dipole and bond dipole are in same direction.
(d) in NH_3, the atomic dipole and bond dipole are in same direction whereas in NF_3 these are in opposite direction.

15. Hydrolysis of adenosine triphosphate involves rupture of

(a) base-sugar bond
(b) sugar-phosphate bond
(c) P—O—P bond
(d) P—N—P bond.

16. $A \xrightarrow{\text{Red hot coke}} CO \xrightarrow{Cl_2} C \xrightarrow{H_2O} 2HCl + A.$

The compounds A and C are

(a) CO_2, $COCl_2$ (b) CO, $COCl_2$
(c) C, CO_2 (d) CO_2, CO

17. In the silver plating of copper, $K[Ag(CN)_2]$ is used instead of $AgNO_3$. The reason is

(a) a thin layer of Ag is formed on Cu
(b) more voltage is required
(c) Ag^+ ions are completely removed from solution
(d) limited availability of Ag^+ ions, as $[Ag(CN)_2]^-$ ion is very stable.

18. The order of reactivity of alcohols towards sodium metal is

(a) primary > secondary > tertiary
(b) primary < secondary < tertiary
(c) primary > secondary < tertiary
(d) primary < secondary > tertiary.

19. An oxide has the following properties:

(i) acts both as a proton donar as well as proton acceptor
(ii) it reacts readily with basic and acidic oxides
(iii) it oxidises Fe at its boiling point.

The oxide is

(a) P_2O_5 (b) SiO_2 (c) H_2O (d) CO_2

20. Consider both these equilibrium to be established simultaneously in a closed container.

$X_{(s)} \rightleftharpoons Y_{(g)} + 2Z_{(g)}$; $A_{(s)} \rightleftharpoons Y_{(g)} + B_{(g)}$

At equilibrium, pressure of Z and B were found to be same and sum of pressure of Z and B is 10 atm more than that of Y. Find ratio of standard Gibbs energy of two reactions.

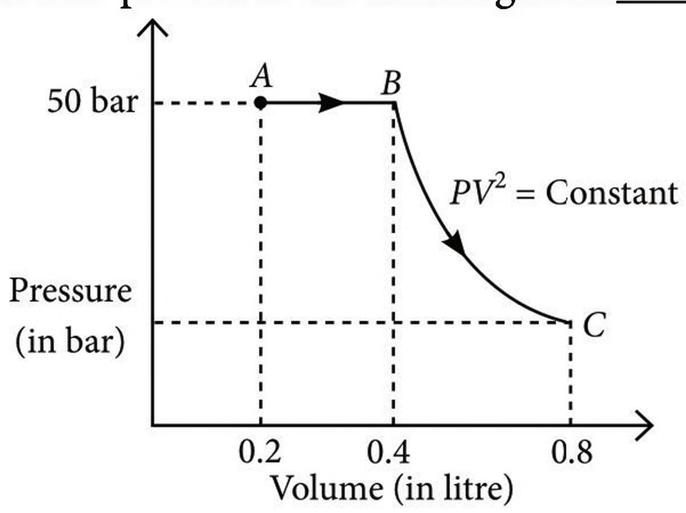
(a) 20 (b) $2.303 \log_{10}20$
(c) $\log_{10}\sqrt[3]{144}$ (d) $\frac{3+\log 12}{2+\log 6}$

SECTION B (NUMERICAL VALUE TYPE)

21. An ionic solid $A^+ B^-$ crystallizes as a body-centred cubic structure. The distance between cation and anion in the lattice is 338 pm. The edge length of the unit cell is _____.

22. 40 mL of 0.05 M solution of sodium sesquicarbonate ($Na_2CO_3.NaHCO_3.2H_2O$) is titrated against 0.05 *M* HCl. When phenolphthalein is used as indicator, x mL HCl is used. In a separate titration of same solution using methyl orange as indicator, y mL of HCl is used. The value of $(y - x)$ is _____.

23. The total work done by a gas (in Joule) if system follows an expansion process as shown in figure is _____.

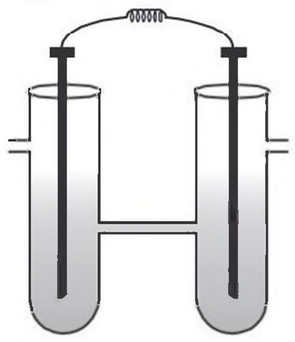


[Given : 1 bar litre = 100 J]

24. A balloon of diameter 20 m weighs 100 kg. Calculate its pay-load, if it is filled with He at 1.0 atm and 27 °C. Density of air is 1.2 kg m^{-3}.
($R = 0.0821$ dm^3 atm K^{-1} mol^{-1})

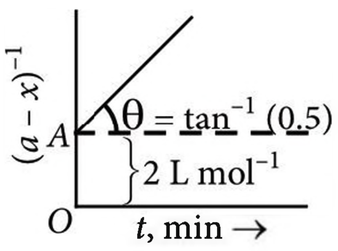
25. In a reaction at equilibrium 'x' moles of the reactant *A* decomposes to give 1 mole each of *C* and *D*. If the fraction of *A* decomposed at equilibrium is independent of initial concentration of *A*, then the value of 'x' is _____.

26. Two weak acid solutions HA_1 and HA_2 each with the same concentration and having pK_a values 3 and 5 are placed in contact with hydrogen electrode (1 atm, 25°C) and are interconnected through a salt bridge. The emf of the cell is _____.



27. Bond distance of C–F in CF_4 and Si–F in SiF_4 are respectively 1.33 Å and 1.54 Å. C–Si bond distance is 1.87 Å. The covalent radius of F atom (ignoring the electronegativity differences) is _____.

28. Given is the graph between $(a - x)^{-1}$ and time.
Hence, rate at the start of the reaction is _____.



29. 0.2 molal acid HX is 20% ionised in solution. $K_f = 1.86$ K molality^{-1}. The freezing point of the solution is _____.

30. Calculate the surface area of a catalyst that adsorbs 10^3 cm^3 of N_2 (reduced of STP) per gram in order to form the monolayer. The effective area occupied by single N_2 molecule on the surface is 1.62×10^{-15} cm^2.

SOLUTIONS

1. **(b):** Higher the value of stability constant, stronger will be the ligand. Thus CN^- is the strongest ligand as the value of stability constant of the complex formed by M^{2+} with CN^- is 10^{27}.

2. **(d):** Small difference in boiling points of C_2F_6 and C_2H_6 is due to the fact that
(i) the F atom is only slightly larger than H, and
(ii) F has low polarizability.

3. **(b):** Eq. wt. of $CaCl_2 \cdot xH_2O = \frac{111+18x}{2} = 55.5 + 9x$

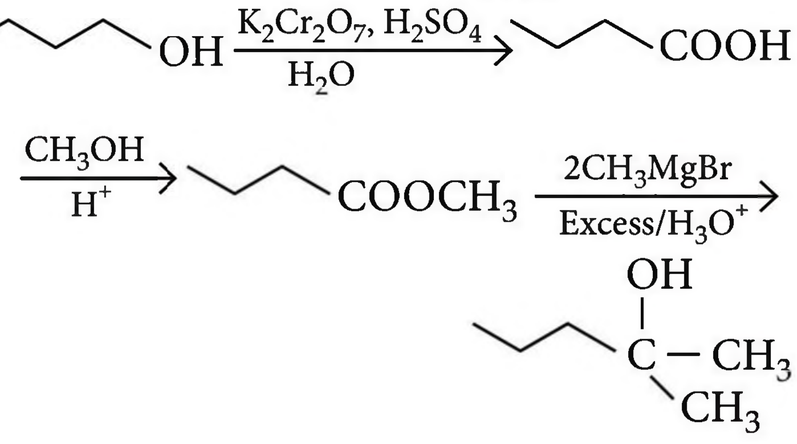
$\therefore$ 5×10^{-3} eq. of $CaCl_2 \cdot xH_2O$
$= 5 \times 10^{-3} \times (55.5 + 9x)$ g of $CaCl_2 \cdot xH_2O$.

$\therefore$ Amount of water obtained

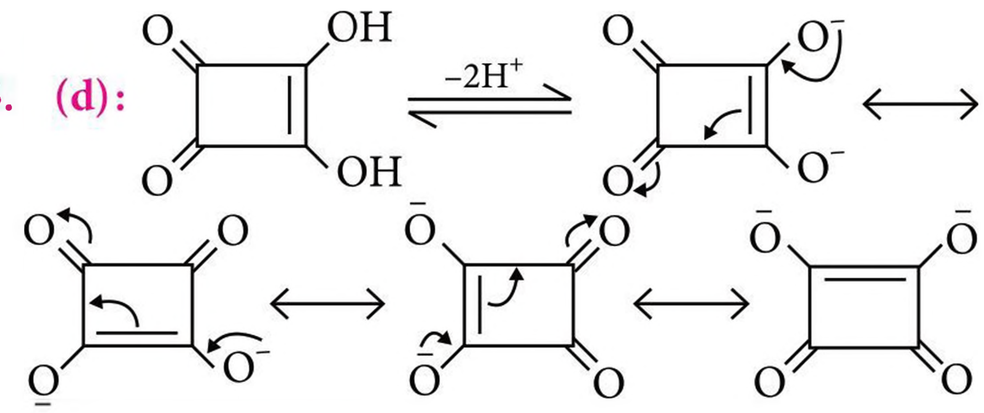
$$= \frac{18x}{111+18x} \times 5 \times 10^{-3} \times (55.5 + 9x) = 9x \times 5 \times 10^{-3}$$

$\therefore$ $9x \times 5 \times 10^{-3} = 0.18$ or $x = \frac{0.18}{9 \times 5} \times 10^3 = 4$

4. **(a):**



5. **(d):**



System is aromatic in nature. So, to gain aromaticity H^+ are easily released.

6. **(b):** Simple sugars *e.g.*, glucose give a positive test with Fehling's solution thus it is used to test the presence of glucose in urine for detecting diabetes.

7. (c) : $4NaCl + K_2Cr_2O_7 + 6H_2SO_4 \longrightarrow 4NaHSO_4 + 2KHSO_4 + 2CrO_2Cl_2 + 3H_2O$

Chromyl chloride

8. (c) : Mg reacts with air to form MgO and Mg_3N_2 both.

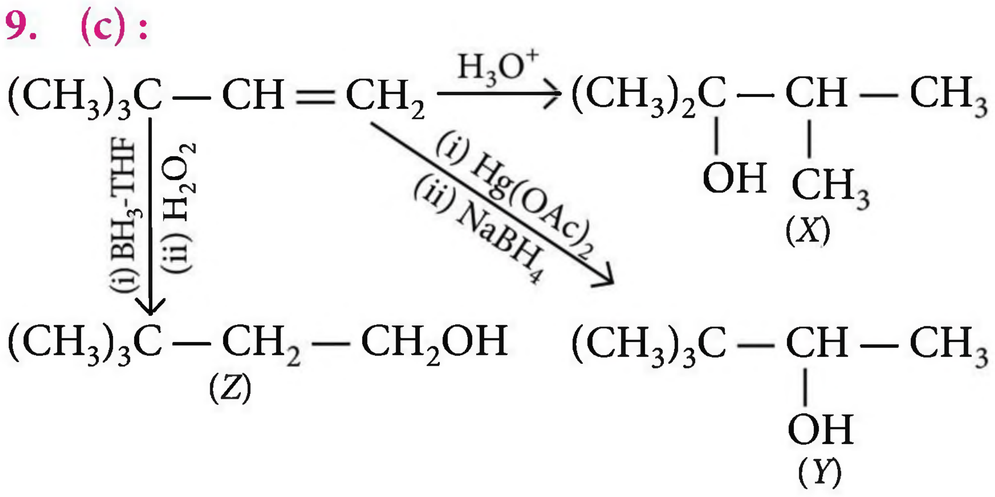
$2Mg + O_2 \longrightarrow 2MgO$; $3Mg + N_2 \longrightarrow Mg_3N_2$;

$Mg_3N_2 + 6H_2O \longrightarrow 3Mg(OH)_2 + 2NH_3\uparrow$

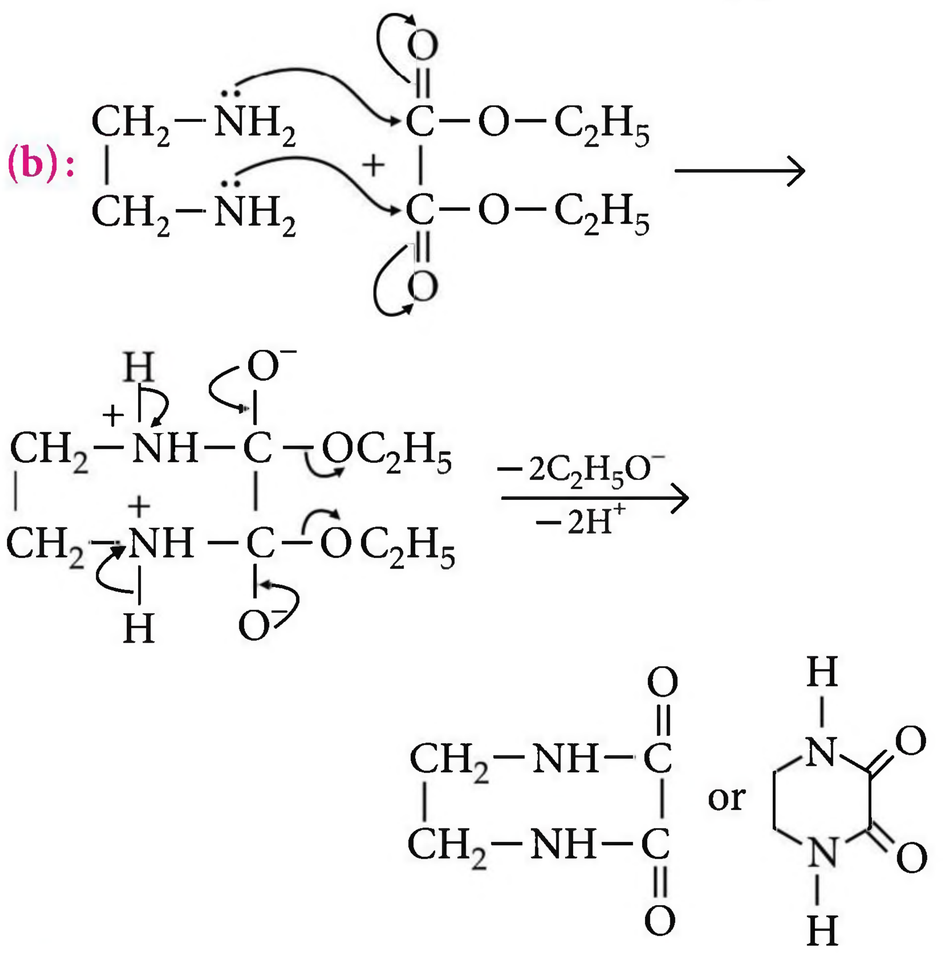
Hydrogen is liberated when Mg reacts with hot water. Rb, K and Ca gives hydrogen gas even with cold water.

$Mg + 2H_2O(hot) \longrightarrow Mg(OH)_2 + H_2$

9. (c) :



10. (b):



11. (c) : Blood red colour with $FeSO_4$/conc. H_2SO_4 by sodium fusion extract

$\Rightarrow$ the compound has both N and S

Black precipitate with lead acetate by sodium fusion extract

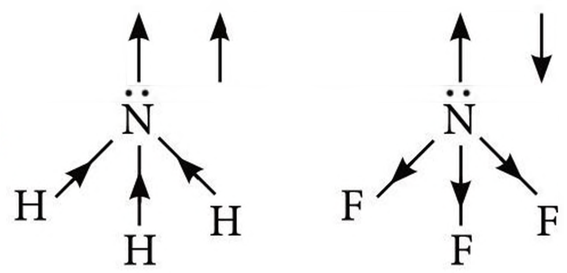
$\Rightarrow$ the compound has S.

Yellow precipitate with $AgNO_3$ by Sodium fusion extract

$\Rightarrow$ the compound has I.

12. (c) **13. (c)**

14. (d):



15. (c)

16. (a) : $\underset{(A)}{CO_2} \xrightarrow{\text{Red hot coke}} CO \xrightarrow{Cl_2} \underset{(C)}{COCl_2} \xrightarrow{H_2O} 2HCl + CO_2\uparrow$

17. (d): In silver plating, $K[Ag(CN)_2]$ is used which provides constant and required supply of Ag^+ ions as $[Ag(CN)_2]^-$ is very stable. But if $AgNO_3$ is used concentration of $[Ag^+]$ in solution will be very large as it is an ionic molecule. In that case Ag will be deposited at faster rate without any uniformity.

18. (a) : Due to $+I$ effect of alkyl groups, the O—H bond in tertiary alcohols is the strongest and hence most difficult to break followed by the O—H bond in secondary alcohols while the O—H bond in primary alcohols is the weakest. Lower the degree of alcohol, higher is the acidic character and easier is the displacement of hydrogen of —OH group by Na.

19. (c)

20. (d): $\underset{t=\text{eq.}}{X_{(s)}} \rightleftharpoons \underset{(a+b)}{Y_{(g)}} + \underset{2a}{2Z_{(g)}}$; $\underset{(a+b)}{A_{(s)}} \rightleftharpoons Y_{(g)} + \underset{(b)}{B_{(g)}}$

Given : $p_Z = p_B \Rightarrow 2a = b$

and $p_Z + p_B = p_Y + 10 \Rightarrow (2a + b) = (a + b) + 10$

$a = 10$ atm and $b = 20$ atm

$K_{P1} = (a + b)(2a)^2 = (30)(400) = 12000$

$K_{P2} = (a + b)(b) = (30)(20) = 600$

$\Delta G = -RT\ln K$

$$\frac{\Delta G_1}{\Delta G_2} = \frac{\ln K_1}{\ln K_2} = \frac{\log 12000}{\log 600} = \frac{3+\log 12}{2+\log 6}$$

21. (390.3) : For a *bcc* unit cell,

$$r^+ + r^- = \sqrt{3} \times \frac{a}{2} \quad \therefore \quad a = \frac{2}{\sqrt{3}}(r^+ + r^-)$$

But $r^+ + r^- = 338$ pm,

$$\therefore \quad a = \frac{2}{\sqrt{3}} \times 338\,\text{pm} = \frac{676}{1.732} = 390.3\,\text{pm}$$

22. (80) : 40 c.c. 0.05 M $Na_2CO_3 \equiv 2$ c.c. M Na_2CO_3

40 c.c. 0.05 M $NaHCO_3 \equiv 2$ c.c. M $NaHCO_3$

When methyl orange is used as an indicator, the volume of HCl used corresponds to total alkali, *i.e.*,

$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2$

$NaHCO_3 + HCl \longrightarrow NaCl + H_2O + CO_2$

$\therefore$ 2 c.c. M $Na_2CO_3 \equiv 4$ c.c. M HCl

and 2 c.c. M $NaHCO_3 \equiv 2$ c.c. M HCl

$\therefore \quad y = 6$ c.c. M HCl

When phenolphthalein is used as an indicator the value of HCl used corresponds to half-neutralization of Na_2CO_3, *i.e.*,

$Na_2CO_3 + HCl \longrightarrow NaHCO_3 + NaCl$

$\therefore \quad 2$ c.c. M $Na_2CO_3 \equiv 2$ c.c. M HCl

$\therefore \quad x = 2$ c.c. M HCl

$\therefore \quad y - x = 6 - 2 = 4$ c.c. M HCl = 80 c.c. 0.05 M HCl

23. (2000) : $P_B V_B^{\,2} = P_C V_C^{\,2}$ or $50 \times (0.4)^2 = P_C \times (0.8)^2$

$$\text{or} \quad P_C = \frac{50 \times 0.4 \times 0.4}{0.8 \times 0.8} = 12.5$$

$w = w_{AB} + w_{BC}$

$$= -50(0.4 - 0.2) + \frac{P_C V_C - P_B V_B}{2 - 1}$$

$$= -50 \times 0.2 + \frac{12.5 \times 0.8 - 50 \times 0.4}{1}$$

$= -10 + (-10) = -20$ bar litre $= -2000$ J

$w = 2000$ J

24. (424.75×10^4) : Weight of balloon

$= 100$ kg $= 10 \times 10^4$ g

$$\text{Volume of balloon} = \frac{4}{3}\pi r^3 = \frac{4}{3} \times \frac{22}{7} \times \left(\frac{20}{2} \times 100\right)^3$$

$= 4190 \times 10^6$ cm^3 $= 4190 \times 10^3$ L

Weight of gas (He) in balloon

$$= \frac{PVM}{RT} = \frac{1 \times 4190 \times 10^3 \times 4}{0.0821 \times 300} = 68.05 \times 10^4 \text{ g}$$

$$\left(\because \quad PV = \frac{w}{M}RT\right)$$

$\therefore$ Total weight of gas and balloon

$= 68.05 \times 10^4 + 10 \times 10^4 = 78.05 \times 10^4$ g

$$\text{Weight of air displaced} = \frac{1.2 \times 4190 \times 10^6}{10^3}$$

$= 502.8 \times 10^4$ g

$\therefore$ Pay load = wt. of air displaced – (wt. of balloon + wt. of gas)

$\therefore$ Pay load $= 502.8 \times 10^4 - 78.05 \times 10^4$

$= 424.75 \times 10^4$ g

25. (2) : $xA \rightleftharpoons C + D$

Initial	a	0	0
At eqm.	$a(1-\alpha)$	$\frac{a\alpha}{x}$	$\frac{a\alpha}{x}$

$$\therefore \quad K = \frac{[C][D]}{[A]^x} = \frac{\frac{a^2\alpha^2}{x^2V^2}}{\frac{[a(1-\alpha)]^x}{V^x}} = \frac{a^{(2-x)}\alpha^2}{x^2(1-\alpha)^x V^{x-2}}$$

If α is independent of a, then $x - 2 = 0 \quad \therefore x = 2$

26. (0.059) : $Pt|H_2(1 \text{ atm})|HA_2||HA_1|H_2(1 \text{ atm})|Pt$

At anode $E_{H/H^+} = E^\circ_{H/H^+} + 0.059\,(pH)_2$.

$(\because \ pH = -\log[H^+])$

At cathode $E_{H/H^+} = E^\circ_{H/H^+} - 0.059\,(pH)_1$

We know, $[H^+] = C\alpha = \sqrt{K_a C}$

$$pH_1 = \frac{1}{2}pK_{a_1} - \frac{1}{2}\log C \ ; \ pH_2 = \frac{1}{2}pK_{a_2} - \frac{1}{2}\log C$$

$E^\circ_{cell} = E^\circ_{H/H^+} + E^\circ_{H^+/H}$

$$= 0.059\left[\frac{1}{2}pK_{a_2} - \frac{1}{2}pK_{a_1}\right] = \frac{0.059}{2}(5-3) = 0.059 \text{ V}$$

27. (0.5) : $r_C + r_F = 1.33$ Å

$r_{Si} + r_F = 1.54$ Å

$r_C + r_{Si} + 2r_F = 2.87$ Å

$r_C + r_{Si} = 1.87$ Å

$2r_F = 2.87$ Å $- 1.87$ Å $\Rightarrow \quad 2r_F = 1.00$ Å

$r_F = 0.5$ Å

28. (0.125) : Since, the graph of t vs $(a-x)^{-1}$ is a straight line, it must be a second order reaction.

$$\therefore \quad k = \frac{1}{t}\left[\frac{1}{(a-x)} - \frac{1}{a}\right] \text{ or } \frac{1}{a-x} = kt + \frac{1}{a}$$

On comparing, slope

$k = \tan\theta = 0.5$ mol^{-1} L min^{-1}

Intercept $(OA) = \frac{1}{a} = 2$ L mol^{-1} or $a = 0.5$ mol L^{-1}

Rate $= k(a)^2 = 0.5 \times (0.5)^2 = 0.125$ mol L^{-1} min^{-1}

29. (–0.45) : Depression in freezing point, $\Delta T_f = i \times K_f \times m$

van't Hoff factor, $i = \frac{1 - \alpha + n\alpha}{1}$,

where n = no. of ions produced by complete dissociation of 1 mole of HX.

$HX \rightleftharpoons H^+ + X^- \Rightarrow \quad n = 2$

$$\therefore \quad i = \frac{1 - 0.2 + 2 \times 0.2}{1} = 1.2$$

$\therefore \quad \Delta T_f = 1.2 \times 1.86 \times 0.2 = 0.45$

Hence, freezing point of solution $(T_f) = 0 - 0.45$

$= -0.45°C$

30. (436×10^{-5}) : 22400 cm^3 of N_2 at STP contain

$= 6.022 \times 10^{23}$ molecules

$\therefore \quad 10^3$ cm^3 of N_2 at STP will contain

$$= \frac{6.022 \times 10^{23} \times 10^3}{22400} \text{ molecules}$$

$= 2.69 \times 10^{22}$ molecules

Area occupied by a single molecules

$= 1.62 \times 10^{-15}$ cm^2

$\therefore \quad$ Area occupied by 2.69×10^{22} molecules of N_2

$= (1.62 \times 10^{-15}) \times (2.69 \times 10^{22})$ cm^2

$= 4.36 \times 10^{-7}$ cm^2 $= 436 \times 10^{-5}$ cm^2

PRACTICE PAPER

NEET 2021

1. Which of the following has highest molar conductivity?
   (a) Diamminedichloroplatinum(II)
   (b) Tetraamminedichlorocobalt(III) chloride
   (c) Potassium hexacyanoferrate(II)
   (d) Pentacarbonyliron(0)

2. Distinction between primary, secondary and tertiary alcohols is done by
   (a) oxidation method
   (b) Lucas test
   (c) Victor Meyer method
   (d) all of these.

3. The volume strength of 1.5 N H_2O_2 solution is
   (a) 4.8 (b) 8.4 (c) 3.0 (d) 8.0

4. The carbohydrate that yields glucose and galactose on acid hydrolysis is
   (a) sucrose (b) lactose
   (c) maltose (d) starch.

5. When ammoniacal solution of $MgSO_4$ is heated with Na_2HPO_4 in presence of NH_4Cl, a white precipitate of _____ is formed.
   (a) $Mg(NH_4)PO_4$ (b) $Mg_3(PO_3)_2$
   (c) $MgSO_4 . MgCl_2$ (d) $MgSO_4 . Mg_3(PO_4)_2$

6. If heavy water is taken as solvent instead of normal water while performing Cannizzaro reaction, the products of the reaction are
   (a) $RCOO^-$ and RCH_2OH
   (b) $RCOO^-$ and RCH_2OD
   (c) $RCOOD$ and RCD_2OD
   (d) $RCOO^-$ and RCD_2OD

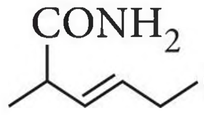
7. Consider the following reduction reactions :
   (i) $Sn^{2+} + 2e^- \rightarrow Sn$; $E^\circ = -0.14$ V
   (ii) $Sn^{4+} + 2e^- \rightarrow Sn^{2+}$; $E^\circ = 0.13$ V
   Match the column I with column II and choose the correct option.

Column I	Column II
(A) $E^\circ_{Sn^{4+}/Sn}$	(i) + 0.005 V
(B) Standard oxidation potential of Sn to Sn^{4+}	(ii) –0.005 V
(C) Disproportionation of Sn^{2+}	(iii) Spontaneous
(D) Oxidation of Sn to Sn^{4+}	(iv) Non-spontaneous

	A	B	C	D
(a)	(i)	(iii)	(ii)	(iv)
(b)	(ii)	(i)	(iv)	(iii)
(c)	(i)	(ii)	(iii)	(iv)
(d)	(ii)	(iv)	(i)	(iii)

8. What would be the name of the structure of silicate in which only one oxygen atom of $[SiO_4]^{4-}$ is shared?
   (a) Three dimensional silicate
   (b) Linear chain silicate
   (c) Sheet silicate
   (d) Pyrosilicate

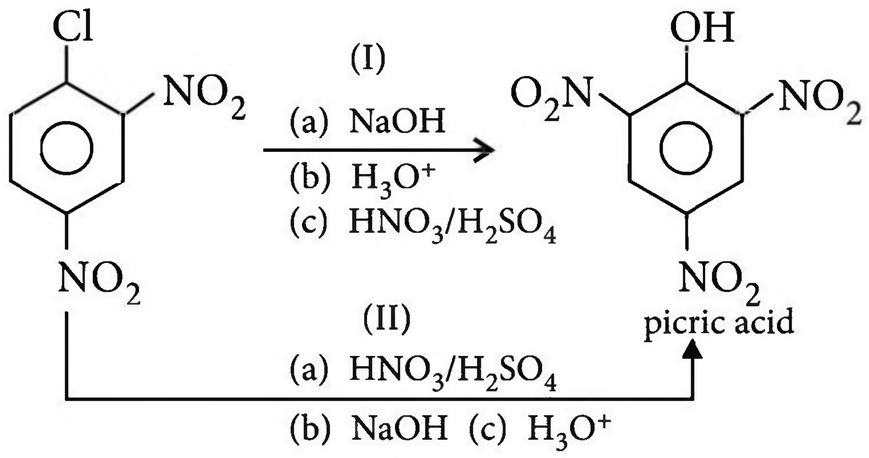
9. The IUPAC name of the compound



   is
   (a) 5-carbamoylhex-1-enal
   (b) 2-carbamoylhex-3-enal
   (c) 2-methyl-6-oxohex-3-enamide
   (d) 6-keto-2-methylhexanamide.

10. A first order reaction is 15% completed in 20 minutes. How long will it take to complete 60% ?
    (a) 123.3 minutes (b) 112.7 minutes
    (c) 145.2 minutes (d) 138.8 minutes

11. Picric acid can be obtained by path I or II from 2, 4-dinitrochlorobenzene.



Which is possible path?

(a) Path I (b) Path II

(c) Both I and II (d) Both are not possible

12. If the equilibrium constant of $BOH \rightleftharpoons B^+ + OH^-$ at 25°C is 2.5×10^{-6}, then equilibrium constant for $BOH + H^+ \rightleftharpoons B^+ + H_2O$ at the same temperature is

(a) 4.0×10^{-9} (b) 4.0×10^{5}

(c) 2.5×10^{8} (d) 2.5×10^{-6}

13. Which of the following statements is not true regarding (+)-lactose?

(a) (+)-Lactose contains 8 –OH groups.

(b) On hydrolysis (+)-lactose gives equal amounts of *D*-(+)-glucose and *D*-(+)-galactose.

(c) (+)-Lactose is a β-glycoside formed by the union of a molecule of *D*-(+)-glucose and a molecule of *D*-(+)-galactose.

(d) (+)-Lactose is a reducing sugar and does not exhibit mutarotation.

14. When excess of KI is added to aqueous $CuSO_4$, the solution acquires dark brown colouration. This is due to the formation of

(a) $CuI_{2(s)}$ (b) $Cu_2I_{2(s)}$

(c) $I^-_{3(aq)}$ (d) $I_{2(s)}$

15. What will be the pressure exerted by a mixture of 3.2 g of methane and 4.4 g of carbon dioxide contained in a 9 dm^3 flask at 27°C?

(a) 0.82 atm (b) 0.55 atm

(c) 0.27 atm (d) 0.41 atm

16. Wavelength of high energy transition of H-atom is 91.2 nm. The corresponding wavelength of He^+ is

(a) 91.2 nm (b) 22.8 nm

(c) 54.5 nm (d) 45.6 nm

17. Sanger's reagent is used for the identification of

(a) N-terminal of a peptide chain

(b) C-terminal of a peptide chain

(c) side chain of amino acids

(d) molecular mass of the peptide chain.

18. Match the species in column I with the shapes in column II and select the correct option.

Column I	**Column II**
(A) H_3O^+	(i) Linear
(B) $HC \equiv CH$	(ii) Angular
(C) ClO_2^-	(iii) Tetrahedral
(D) NH_4^+	(iv) Pyramidal

	A	**B**	**C**	**D**
(a)	(i)	(ii)	(iv)	(iii)
(b)	(iv)	(i)	(ii)	(iii)
(c)	(i)	(ii)	(iii)	(iv)
(d)	(iv)	(ii)	(i)	(iii)

19. 43. Determine the standard reduction potential for the half cell reaction, $Cl_2 + 2e^- \longrightarrow 2Cl^-$.

(Given : $Pt^{2+} + 2Cl^- \longrightarrow Pt + Cl_2$, $E^\circ_{cell} = -0.15$ V

$Pt^{2+} + 2e^- \longrightarrow Pt$, $E^\circ = 1.20$ V)

(a) 1.05 V (b) – 1.05 V

(c) – 1.35 V (d) 1.35 V

20. The gold number of some colloidal solutions are given as :

Colloidal solution	**Gold number**
A	0.01
B	2.5
C	20

The protective nature of these colloidal solutions follows the order

(a) $C > B > A$ (b) $A > B > C$

(c) $A = B = C$ (d) $B > A > C$

21. Among 2-chloropropanoic acid, 3-chloropropanoic acid, 2,2-dichloroacetic acid and propanoic acid, the K_a values will be in the order,

(a) 2,2-dichloroacetic acid > 2-chloropropanoic acid > 3-chloropropanoic acid > propanoic acid

(b) 3-chloropropanoic acid > 2-chloropropanoic acid > 2,2-dichloroacetic acid > propanoic acid

(c) 2,2-dichloroacetic acid > 3-chloropropanoic acid > 2-chloropropanoic acid > propanoic acid

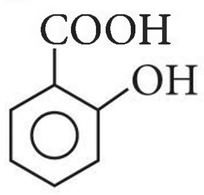
(d) 2,2-dichloroacetic acid > propanoic acid > 2-chloropropanoic acid > 3-chloropropanoic acid

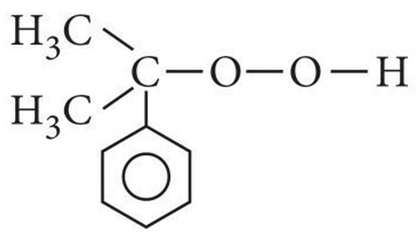
22. A metal (atomic weight = 100) has *ccp* lattice of edge length 400 pm. The correct value for density of the metal (in g cm^{-3}) is (Use $N_A = 6 \times 10^{23}$)

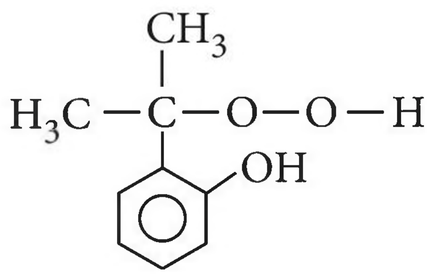
(a) 1.042 (b) 5.021

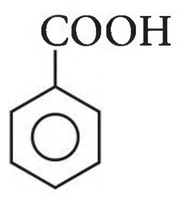
(c) 10.42 (d) 2.4

23. Phenol is distilled with Zn dust followed by Friedel–Crafts alkylation with propyl chloride in the presence of $AlCl_3$ to give a compound *B*. *B* is oxidised in the presence of air to form the compound *C*. The structural formula of *C* is

(a) 

(b) 

(c) 

(d) 

24. The lattice enthalpy and hydration enthalpy of four compounds are given below :

Compounds	Lattice enthalpy (in kJ mol^{-1})	Hydration enthalpy (in kJ mol^{-1})
P	+ 780	– 920
Q	+ 1012	– 812
R	+ 828	– 878
S	+ 632	– 600

The pair of compounds which is soluble in water is

(a) *P* and *Q* (b) *Q* and *R*
(c) *R* and *S* (d) *P* and *R*

25. A mixture of ethane (C_2H_6) and ethene (C_2H_4) occupies 40 L at 1.00 atm and 400 K. The mixture reacts completely with 130 g of O_2 to produce CO_2 and H_2O. Assuming ideal gas behaviour, the mole fraction of C_2H_4 in the mixture is

(a) 0.66 (b) 0.34 (c) 0.50 (d) 0.84

26. An unknown element forms an oxide. What will be the equivalent weight of the element if the oxygen content is 20% by weight?

(a) 16 g (b) 32 g
(c) 8 g (d) 64 g

27. In chromic acid anhydride (CrO_3), Cr has d^0 configuration but it is bright orange coloured solid, the colour is due to

(a) *d* - *d* transition
(b) charge transfer ($L \rightarrow M$) transition
(c) charge transfer ($M \rightarrow L$) transition
(d) *p* - *d* transition.

28. Match the polymers given in column I with their chemical names given in column II.

	Column I		Column II
P.	Nylon 6	1.	Polyvinyl chloride
Q.	PVC	2.	Polyacrylonitrile
R.	Acrilan	3.	Polycaprolactum
S.	Natural rubber	4.	*cis*-Polyisoprene

	P	Q	R	S
(a)	1	2	3	4
(b)	4	3	1	2
(c)	3	1	4	2
(d)	3	1	2	4

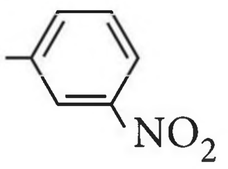
29. If the concentration of glucose ($C_6H_{12}O_6$) in blood is 0.9 g L^{-1}, what will be the molarity of glucose in blood?

(a) 5 M (b) 50 M
(c) 0.005 M (d) 0.5 M

30. Select the process that represents smelting.

(a) $Al_2O_3 + 3H_2O \xrightarrow{\Delta} 2Al(OH)_3$
(b) $ZnCO_3 \xrightarrow{\Delta} ZnO + CO_2$
(c) $Fe_2O_3 + 3C \xrightarrow{\Delta} 2Fe + 3CO$
(d) $2Pb + O_2 \xrightarrow{\Delta} 2PbO$

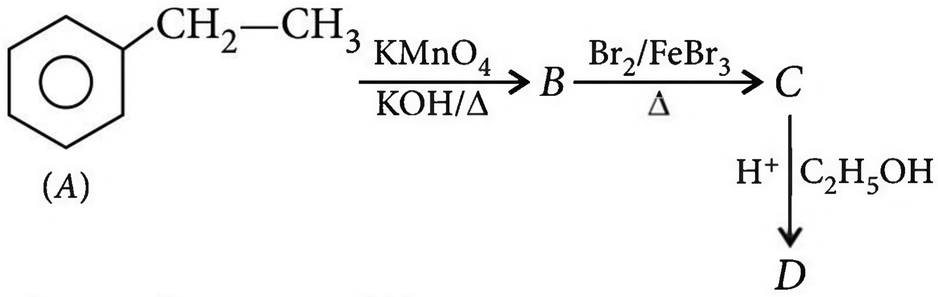
31. Which of the following species is the strongest base?

(a) –OH (b) –*OR*
(c) $-OC_6H_5$ (d) 

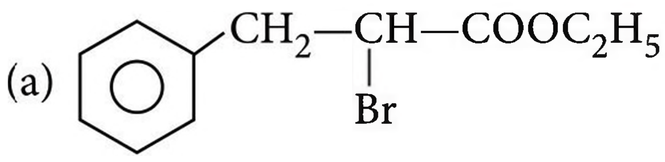
32. The thermal stability of the hydrides of O, S, Se and Te varies in the order

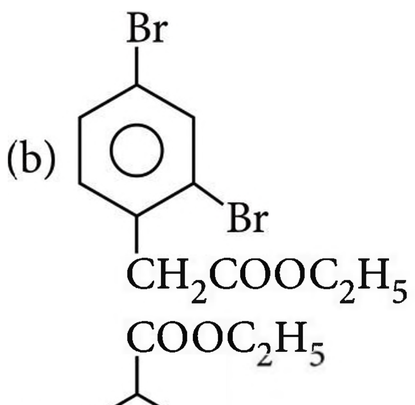
(a) $H_2Te > H_2Se > H_2S > H_2O$
(b) $H_2O > H_2S > H_2Se > H_2Te$
(c) $H_2O > H_2Se > H_2Te > H_2S$
(d) $H_2S > H_2O > H_2Se > H_2Te$

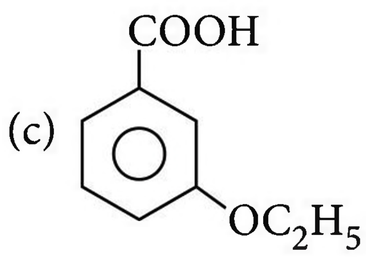
33. In a set of reactions, ethyl benzene yielded a product *D*.

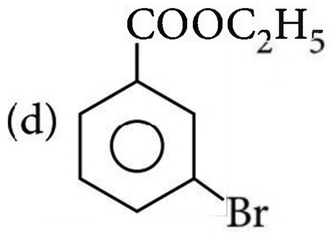


The product *D* would be

(a) 

(b) 

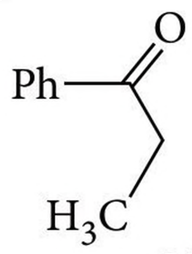
(c) 

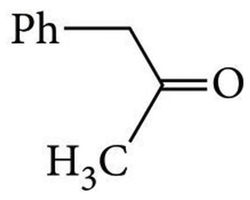
(d) 

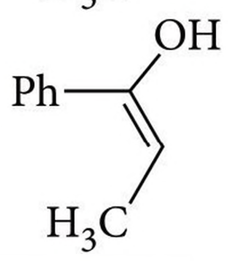
34. In the following reaction,

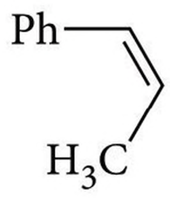
$$Ph{-}C{\equiv}C{-}CH_3 \xrightarrow[H_2O]{Hg^{2+}/H^+} A$$

A is

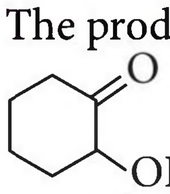
(a) 

(b) 

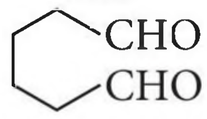
(c) 

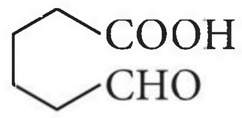
(d) 

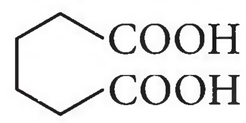
35. The product obtained when,

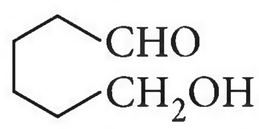


is oxidised with HIO_4 is

(a) 

(b) 

(c) 

(d) 

36. An energy of 24.6 eV is required to remove one of the electrons from a helium atom. The total energy required to remove both the electrons from helium atom is

(a) 38.2 eV (b) 49.2 eV
(c) 51.8 eV (d) 79.0 eV

37. *m*-Bromoaniline can be prepared by

(a) $C_6H_6 \xrightarrow[H_2SO_4]{HNO_3} \xrightarrow[(ii)\ NaOH,\ H_2O]{(i)\ Sn-HCl} \xrightarrow[H_2O]{Br_2}$

(b) $C_6H_6 \xrightarrow[FeBr_3]{Br_2} \xrightarrow[H_2SO_4]{HNO_3} \xrightarrow[Pt]{H_2}$

(c) $m\text{-}BrC_6H_4COOH \xrightarrow{SOCl_2} \xrightarrow{NH_3} \xrightarrow{Br_2,\ NaOH}$

(d) $C_6H_5NH_2 \xrightarrow[Cu_2Br_2]{NaNO_2,\ HCl} \xrightarrow{NaNH_2}$

38. Following data is given at 25°C,

$Ag + I^- \longrightarrow AgI + e^-$; $E^\circ = 0.152$ V

$Ag \longrightarrow Ag^+ + e^-$; $E^\circ = 0.800$ V

What is the value of log K_{sp} for AgI?

(a) – 37.83 (b) – 16.13
(c) – 8.12 (d) + 8.612

39. The ozone in the stratosphere is destroyed by

(a) $^\bullet Cl$ (b) $^\bullet OH$
(c) $^\bullet H$ (d) $^\bullet ClO$

40. Chloramine - T is an

(a) disinfectant (b) antiseptic
(c) analgesic (d) antipyretic

41. The successive ionisation enthalpy values for an element *X* are given as :

1st ionisation enthalpy = 410 kJ mol^{-1}
2nd ionisation enthalpy = 820 kJ mol^{-1}
3rd ionisation enthalpy = 1100 kJ mol^{-1}
4th ionisation enthalpy = 1500 kJ mol^{-1}
5th ionisation enthalpy = 3200 kJ mol^{-1}

Find out the number of valence electrons for the atom *X*.

(a) 4 (b) 3 (c) 5 (d) 2

42. $CH_3CH_2NH_2$ contains a basic NH_2 group, but CH_3CONH_2 does not because

(a) acetamide is amphoteric in character
(b) in ethyl amine the electron pair on N-atom is delocalised by resonance
(c) in ethyl amine there is no resonance while in acetamide the lone pair of electrons on N-atom is delocalised and is less available for protonation
(d) all of these.

43. Sulphur trioxide can be obtained by which of the following reaction?

(a) $CaSO_4 + C \xrightarrow{\Delta}$ (b) $Fe_2(SO_4)_3 \xrightarrow{\Delta}$
(c) $S + H_2SO_4 \xrightarrow{\Delta}$ (d) $H_2SO_4 + PCl_5 \xrightarrow{\Delta}$

44. The correct order of the ligands, OH^-, NO_3^-, PPh_3, pyridine, according to their increasing field strength is

(a) $NO_3^- < OH^- <$ pyridine $< PPh_3$
(b) $OH^- < NO_3^- < PPh_3 <$ pyridine
(c) $OH^- < NO_3^- <$ pyridine $< PPh_3$
(d) $NO_3^- < OH^- < PPh_3 <$ pyridine

45. For the reaction,

$$H_{2(g)} + \frac{1}{2}O_{2(g)} \longrightarrow H_2O_{(l)}$$

$B.E._{(H-H)} = x_1$; $B.E._{(O=O)} = x_2$ and $B.E._{(O-H)} = x_3$. If the latent heat of vaporisation of water liquid into water vapour = x_4, then $\Delta_f H$ (heat of formation of liquid water) is

(a) $x_1 + \frac{x_2}{2} - x_3 + x_4$ (b) $2x_3 - x_1 - \frac{x_2}{2} - x_4$

(c) $x_1 + \frac{x_2}{2} - 2x_3 - x_4$ (d) $x_1 + \frac{x_2}{2} - 2x_3 + x_4$

SOLUTIONS

1. (c) : $K_4[Fe(CN)_6] \rightleftharpoons 4K^+ + [Fe(CN)_6]^{4-}$

Potassium hexacyanoferrate(II) gives a total of 5 ions in aqueous solution thus, it has the highest molar conductivity whereas other complexes will give lesser number of ions.

2. (d)

3. (b): The decomposition reaction of H_2O_2 is

$$2H_2O_2 \longrightarrow 2H_2O + O_2$$

Thus, 2 mol (or 4 equivalents) of H_2O_2 would give 1 mol (22.4 L at STP) of O_2. 1 L of 4 equivalents of H_2O_2 has a volume strength of 22.4. Thus,

1 L of 1.5 equivalents (1.5 N) of $H_2O_2 = \frac{22.4 \times 1.5}{4} = 8.4$

4. (b): Lactose on hydrolysis with acetic acid gives glucose and galactose.

5. (a) : $Mg^{2+} + NH_3 + HPO_4^{2-} \longrightarrow \underset{\text{White ppt.}}{Mg(NH_4)PO_4}$

6. (b): $RCH{=}O \xrightarrow[D_2O]{NaOH} R{-}\underset{OH}{\overset{O^-}{\underset{|}{\overset{|}{C}}}}{-}H \xrightleftharpoons{D_2O}$

$$R{-}\underset{OD}{\overset{O^-}{\underset{|}{\overset{|}{C}}}}{-}H \xrightarrow{RCH{=}O} \left[R{-}\underset{OD}{\overset{O}{\underset{|}{\overset{\|}{C}}}}{-}OD + RCH_2O^-\right] \xrightarrow{D^+ \text{ transfer}} RCOO^- + RCH_2OD$$

7. (b): (A) $Sn^{2+} + 2e^- \longrightarrow Sn$; $E^\circ = -0.14$ V ...(i)

$Sn^{4+} + 2e^- \longrightarrow Sn^{2+}$; $E^\circ = 0.13$ V ...(ii)

On adding equations (i) and (ii),

$Sn^{4+} + 4e^- \longrightarrow Sn$;

$$E^\circ_{Sn^{4+}/Sn} = \frac{n_1E_1^\circ + n_2E_2^\circ}{n_1 + n_2} = \frac{2\times(-0.14) + 2\times 0.13}{4}$$

$= -0.005$ V

(B) As, $E^\circ_{Sn^{4+}/Sn} = -0.005$ V

$E^\circ_{Sn/Sn^{4+}} = -E^\circ_{Sn^{4+}/Sn} = +0.005$ V

(C) Disproportionation reaction :

$2Sn^{2+} \longrightarrow Sn^{4+} + Sn$

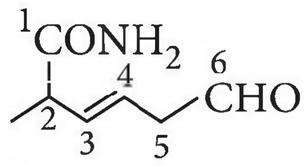
$E^\circ_{cell} = E^\circ_{Sn^{2+}/Sn} - E^\circ_{Sn^{4+}/Sn^{2+}}$

$= -0.14 - 0.13 = -0.27$ V; the reaction is non-spontaneous.

(D) Since $E^\circ_{Sn/Sn^{4+}} > 0$, oxidation of Sn to Sn^{4+} will be spontaneous.

8. (d)

9. (c) :



2-Methyl-6-oxohex-3-enamide

10. (b): For the first order reaction,

$$k = \frac{2.303}{t}\log\frac{[A]_0}{[A]_t}$$

If $[A]_0$ = a, $[A]_t = a - \frac{a\times 15}{100} = 0.85a, t = 20$ min

$$k = \frac{2.303}{20}\log\frac{a}{0.85a} = \frac{2.303}{20}\times 0.0706$$

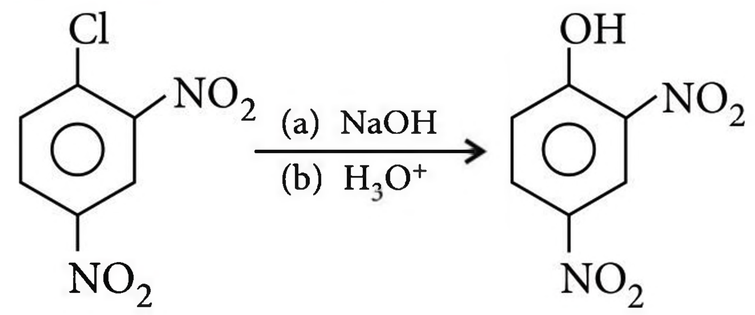
$= 8.13 \times 10^{-3}$ min^{-1}

In second case, if $[A]_0$ = a, $[A]_t = a - \frac{a\times 60}{100} = 0.40a$ and time, t = ?

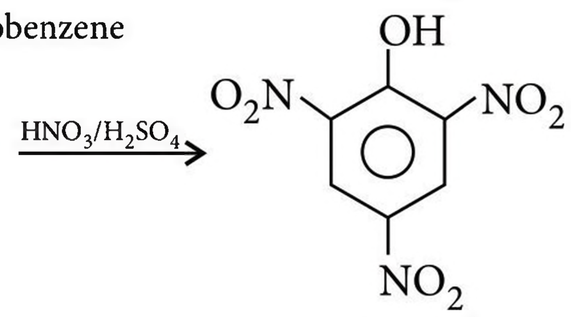
Now, $t = \frac{2.303}{k}\log\frac{[A]_0}{[A]_t} = \frac{2.303}{8.13\times 10^{-3}}\log\frac{a}{0.40a}$

$= \frac{2.303}{8.13\times 10^{-3}}\times 0.3979 = 112.7$ min

11. (a) : Path I is feasible since –OH group after I (a) and I (b) activate the benzene ring for nitration. –Cl and two $-NO_2$ groups deactivate the ring in path II hence, nitration is not possible.



2,4-Dinitrochlorobenzene



Picric acid

In path I, due to $-NO_2$ group C — Cl bond weakens which makes nucleophilic substitution reaction possible. Also $-NO_2$ (deactivating group) prevents oxidation of 2,4-dinitrophenol when further nitrated.

12. (c) : $BOH \rightleftharpoons B^+ + \bar{O}H$; $(K_b = 2.5 \times 10^{-6})$

$$H^+ + \bar{O}H \rightleftharpoons H_2O; \left(K = \frac{1}{K_w}\right)$$

$$BOH + H^+ \rightleftharpoons B^+ + H_2O;\ K' = ?$$

$$\therefore \quad K' = K_b \times \frac{1}{K_w} = \frac{2.5\times10^{-6}}{10^{-14}} = 2.5 \times 10^8$$

13. (d): (+)–Lactose is a reducing sugar and shows mutarotation.

14. (c) : $2CuSO_4 + 4KI \longrightarrow Cu_2I_2 + 2K_2SO_4 + I_2$;

$I_{2(s)} + I^-_{(aq)} \longrightarrow I^-_{3(aq)}$ (dark brown)

15. (a) : $p = \frac{n}{V}RT = \frac{w}{M}\frac{RT}{V}$

$$p_{CH_4} = \left(\frac{3.2}{16}\right) \times \frac{0.0821\times300}{9} = 0.55 \text{ atm}$$

$$p_{CO_2} = \left(\frac{4.4}{44}\right) \times \frac{0.0821\times300}{9} = 0.27 \text{ atm}$$

$P_{Total} = 0.55 + 0.27 = 0.82$ atm

16. (b): For H-atom :

$$\frac{1}{\lambda_H} = R_H\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] \quad ...(i)$$

For He^+ ion : $\frac{1}{\lambda_{He^+}} = R_H \times Z^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$ ...(ii)

$$\therefore \quad \lambda_{He^+} = \lambda_H \times \frac{1}{Z^2} = 91.2 \times \frac{1}{2^2} = 22.8 \text{ nm}$$

$(\because \lambda H = 91.2 \text{ nm})$

17. (a) : Sanger's reagent is used for the identification of N-terminal residue of a polypeptide.

18. (b) **19. (d)**

20. (b): Higher the gold number, lower will be the protective power of a colloidal solution.

21. (a) : Acidic strength $\propto K_a$ value

Due to –I effect of –Cl group, chloropropanoic acid is stronger acid than propanoic acid. Further, greater the number of electron withdrawing substituents, greater will be the acidic strength.

Inductive effect decreases rapidly with distance and so is the acidic strength. Hence, the correct order of acidic strength (or K_a values) will be

$$Cl_2CHCOOH > ClCH_2\underset{\displaystyle CH_3}{\underset{|}{C}}HCOOH > ClCH_2CH_2COOH > CH_3CH_2COOH$$

2, 2-Dichloroacetic acid; 2-Chloropropanoic acid; 3-Chloropropanoic acid; Propanoic acid

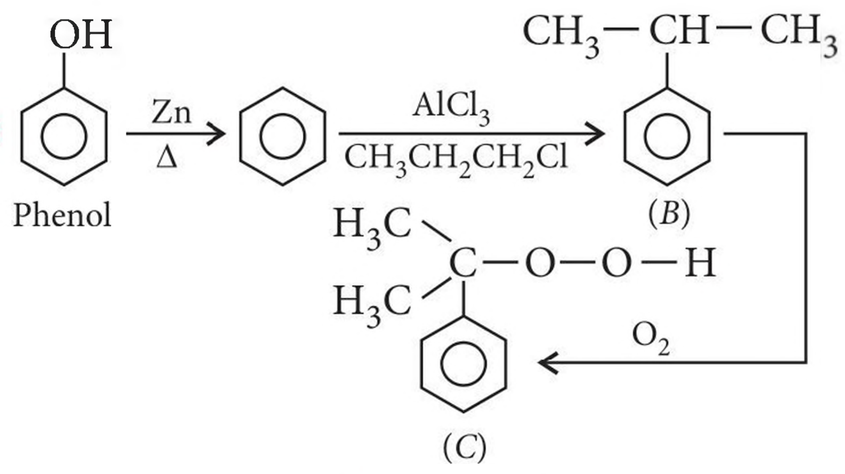
22. (c) : Z for *ccp*, *i.e.*, *fcc* = 4

$$d = \frac{Z\times M}{N_A \times a^3}$$

$$d = \frac{4\times100}{(400)^3\times10^{-30}\times6\times10^{23}} = \frac{4\times100\times10^{30}}{64\times10^6\times6\times10^{23}}$$

$$= \frac{1000}{96} \approx 10.42 \text{ g cm}^{-3}$$

23. (b):



Phenol (C)

24. (d): A compound is soluble if hydration enthalpy (released) is greater than lattice enthalpy.

25. (b): For a gaseous mixture of C_2H_6 and C_2H_4,

$$PV = nRT$$

$\therefore \quad 1 \times 40 = n \times 0.082 \times 400 \Rightarrow n = 1.2195$

$\therefore$ Total moles of C_2H_6 and $C_2H_4 = 1.2195$

Let number of moles of C_2H_6 and C_2H_4 be a and b respectively.

$a + b = 1.2195$ ...(i)

$C_2H_6 + 7/2O_2 \longrightarrow 2CO_2 + 3H_2O$

$C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$

$\therefore$ Number of moles of O_2 needed for complete reaction of the mixture

$$= \frac{7a}{2} + 3b = \frac{130}{32} \quad ...(ii)$$

Solving eqs. (i) and (ii), we get, $a = 0.808$; $b = 0.4115$

$\therefore$ Mole fraction of $C_2H_6 = 0.808/1.2195 = 0.66$

and mole fraction of $C_2H_4 = \frac{0.4115}{1.2195} = 0.34$

26. (b): Given that oxygen content is 20% by weight, then

eq. wt. of unknown element $= \frac{80}{20} \times 8 \text{ g} = 32 \text{ g}$

27. (b): The colour of CrO_3 (d^0 configuration) is due to charge transfer from ligand (oxygen) to metal (chromium) and not due to *d-d* transition.

28. (d)

29. (c) : Molarity of glucose in blood

$$= \frac{\text{No. of moles of glucose}}{\text{Volume of blood (in L)}}$$

$$= \frac{\text{Wt. of glucose}}{\text{Mol. wt. of glucose} \times \text{Volume of blood (in L)}}$$

[Mol. mass of glucose = 180 g/mol]

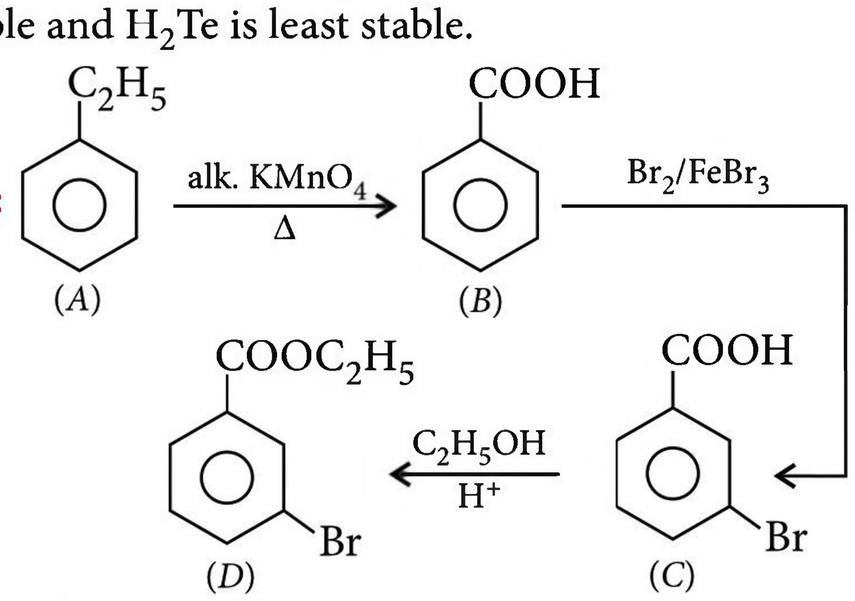
$$= \frac{0.9\ \text{g}}{180\ \text{g/mol} \times 1\ \text{L}} = 5 \times 10^{-3}\ \text{mol L}^{-1} = 0.005\ \text{M}$$

30. (c) : Smelting is the process of reduction using carbon as a reducing agent.

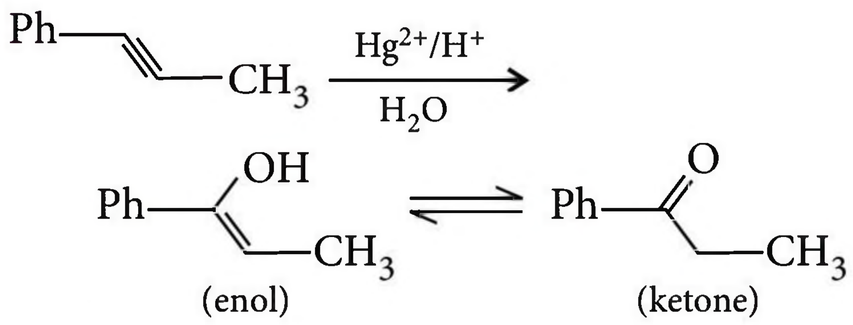
31. (b): ^-OR is the strongest base since *R* (alkyl) group is an electron releasing group which increases electron density on oxygen.

32. (b): Thermal stability decreases as the size of atom increases (down the group). Thus, H_2O is most stable and H_2Te is least stable.

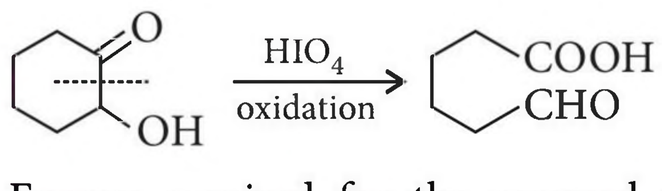
33. (d):



34. (a) :



35. (b):

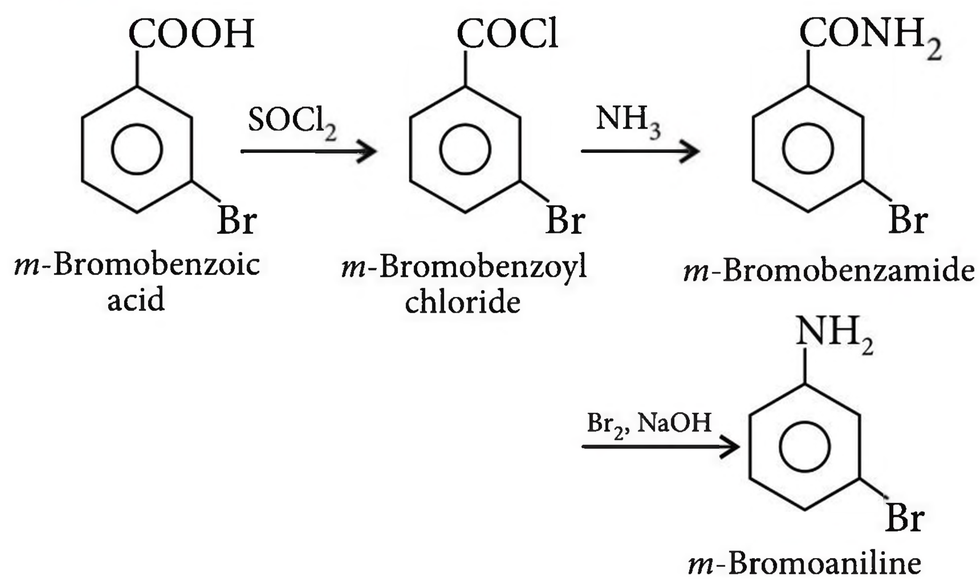


36. (d): Energy required for the removal of second electron from He-atom

$$= +13.6\frac{Z^2}{n^2} = 13.6 \times \frac{2^2}{1^2} = 54.4\ \text{eV}$$

Hence, the total energy required for the removal of both the electrons = 24.6 + 54.4 = 79.0 eV

37. (c) :



38. (b): $Ag + I^- \longrightarrow AgI + e^-,\ E_1^\circ = 0.152\ V$

$Ag^+ + e^- \longrightarrow Ag,\ E_2^\circ = 0.800\ V$

$Ag^+ + I^- \longrightarrow AgI,\ E^\circ = 0.952\ V$

At equilibrium, $E^\circ = \frac{2.303RT}{F}\log K_c$

But $K_c = \frac{[AgI]}{[Ag^+][I^-]} = \frac{1}{K_{sp}}$

$\therefore \quad 0.952 = -\frac{2.303RT}{F}\log K_{sp} = -0.059 \log K_{sp}$

or $\log K_{sp} = -16.13$

39. (a) **40. (a)**

41. (a) : Removal of 5th electron requires almost more than double the energy required for removing 4th electron. Therefore, the valence electrons should be 4.

42. (c)

43. (b): $Fe_2(SO_4)_3 \longrightarrow Fe_2O_3 + 3SO_3$

44. (a) : $NO_3^- < OH^- < Py < PPh_3$

Weak field ligand — Strong field ligand

45. (c) : $\Delta_f H = (B.E.)_{\text{reactants}} - (B.E.)_{\text{products}}$

But all the species must be in gaseous state, so in product $[H_2O_{(l)} \longrightarrow H_2O_{(g)}]\ \Delta H_{vap}$ must be added.

Hence for the reaction, $H_{2(g)} + \frac{1}{2}O_{2(g)} \longrightarrow H_2O_{(l)}$

$$\Delta_f H = \left[(B.E.)_{H-H} + \frac{1}{2}(B.E.)_{O=O}\right] - [\Delta H_{vap} + 2(B.E.)_{O-H}]$$

$$= x_1 + \frac{x_2}{2} - [x_4 + 2x_3] \Rightarrow x_1 + \frac{x_2}{2} - x_4 - 2x_3$$

JEE 2021 PRACTICE PAPER ADVANCED

PAPER - I

Section 1 (Maximum Marks : 18)

- ***This section contains SIX (06) questions.***
- ***Each question has FOUR options. ONLY ONE of these four options is the correct answer.***
- ***For each question, choose the option corresponding to the correct answer.***
- ***Answer to each question will be evaluated according to the following marking scheme :***

Full Marks :	***+3***	***If ONLY the correct option is chosen.***
Zero Marks :	***0***	***If none of the options is chosen (i.e. the question is unanswered).***
Negative Marks :	***–1***	***In all other cases.***

1. For two gases, A and B with molecular weights M_A and M_B, it is observed that at a certain temperature T, the mean velocity of A is equal to the u_{rms} of B. Thus, the mean velocity of A can be made equal to the mean velocity of B, if

(a) A is at temperature T and B at T'; $T > T'$

(b) both A and B are raised to a higher temperature

(c) both A and B are lowered in temperature

(d) none of these.

2. To an acidic solution of an anion, a few drops of $KMnO_4$ solution are added. Which of the following, if present, will not decolourise the $KMnO_4$ solution?

(a) CO_3^{2-} (b) NO_2^- (c) S^{2-} (d) Cl^-

3. In compounds of type ECl_3, where E = B, P, As or Bi, the angles Cl—E—Cl for different E are in the order

(a) B > P = As = Bi (b) B > P > As > Bi

(c) B < P = As = Bi (d) B < P < As < Bi

4. Pure ammonia is placed in a vessel at a temperature when its dissociation constant (α) is appreciable. At equilibrium,

(a) K_p does not change significantly with pressure

(b) α does not change with pressure

(c) concentration of NH_3 does not change with pressure

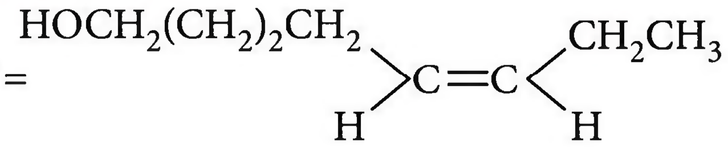
(d) concentration of H_2 is less than that of N_2.

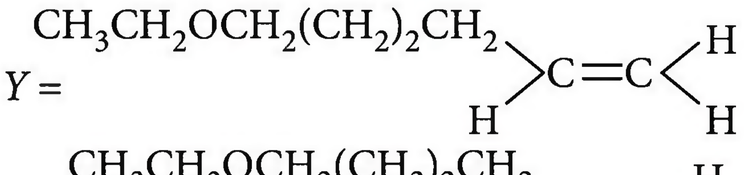
5. $HO-CH_2-(CH_2)_2-CH_2-C\equiv CH\ (A) \xrightarrow{NaNH_2} B$

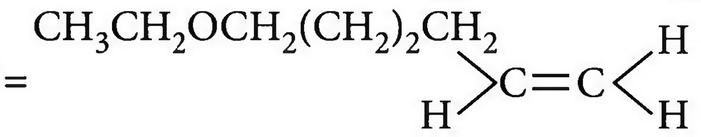
Final product $\xleftarrow[\text{Lindlar's catalyst}]{H_2} D \xleftarrow{EtOH} C \xleftarrow{CH_3CH_2Br} B$

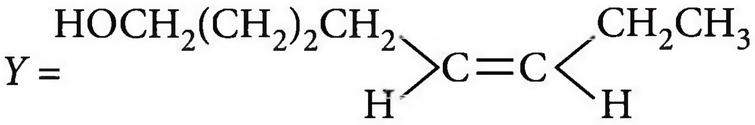
If A is treated with excess of $NaNH_2$, the final product is X and if A is treated with only one equivalent of $NaNH_2$, the final product is Y. (Remaining reagents are reacted as indicated in both the cases). Which of the following justify X and Y correctly?

(a) X and Y both are same molecules but X will be in higher yield.

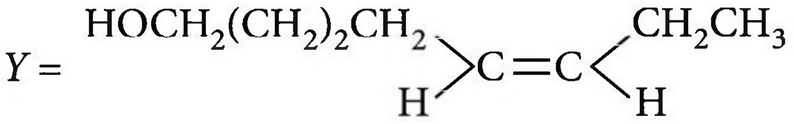
(b) $X =$ 

$Y =$ 

(c) $X =$ 

$Y =$ 

(d) $X = HOCH_2(CH_2)_2CH_2CH_2CH_2CH{=}CH_2$

$Y =$ 

6. Match list I with list II and choose the correct matching codes from the choices given below:

	List I		**List II**
A.	PCl_5	1.	Linear
B.	IF_7	2.	Pyramidal
C.	H_3O^+	3.	Trigonal bipyramidal
D.	ClO_2	4.	Tetrahedral
E.	NH_4^+	5.	Pentagonal bipyramidal
		6.	Angular

(a) A-3, B-5, C-2, D-1, E-4

(b) A-3, B-5, C-4, D-1, E-2

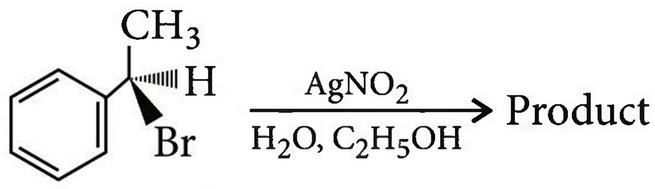
(c) A-3, B-5, C-6, D-1, E-2

(d) A-3, B-5, C-2, D-6, E-4

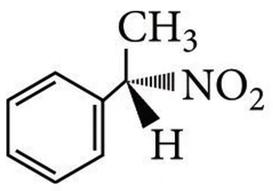
Section 2 (Maximum Marks : 24)

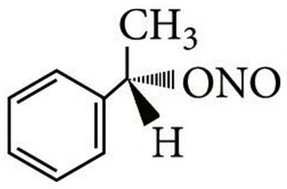
- ***This section contains SIX (06) questions.***
- ***Each question has FOUR options. ONE OR MORE THAN ONE of these four option(s) is (are) correct answer(s).***
- ***For each question, choose the option(s) corresponding to (all) the correct answer(s).***
- ***Answer to each question will be evaluated according to the following marking scheme :***

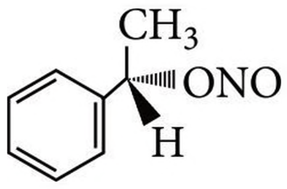
Full Marks :	***+4***	***If only (all) the correct option(s) is (are) chosen.***
Partial Marks :	***+3***	***If all the four options are correct but ONLY three options are chosen.***
Partial Marks :	***+2***	***If three or more options are correct but ONLY two options are chosen, both of which are correct.***
Partial Marks :	***+1***	***If two or more options are correct but ONLY one option is chosen and it is a correct option.***
Zero Marks :	***0***	***If none of the options is chosen (i.e. the question is unanswered).***
Negative Marks :	***–2***	***In all other cases.***

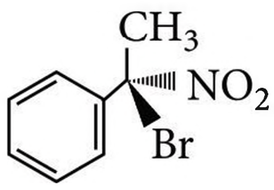
7. 

The main product is

(a) 

(b) 

(c)  + Enantiomer

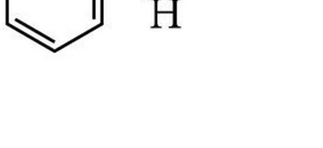
(d)  + Enantiomer

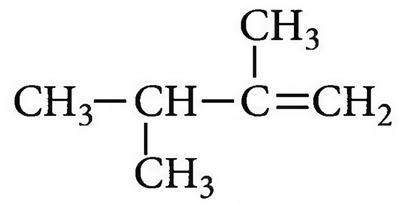
8. Which of the following easily undergo(es) nucleophilic substitution by S_N1 mechanism in butanol?

(a) $C_6H_5CH_2Br$ (b) $BrCH_2CH{=}CH_2$

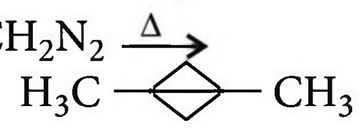
(c) $(CH_3)_3CBr$ (d) $(CH_3)_3CCH_2Br$

9. Which of the following reactions are properly interpreted?

(a) $R_2C{=}CR_2 + :CBr_2 \longrightarrow$  $\xrightarrow{Mg}$ $R_2C{=}C{=}CR_2$

(b) $Me_2C{=}CMe_2 \xrightarrow{HCl}$ $\xrightarrow{t\text{-BuOK}}$ 

(c) $(CH_3)_3N^+ - CH_2 - CH_2 - OH \xrightarrow[\Delta]{Ag_2O}$ $CH_3 - CHO$

(d) $CH_3 - C{\equiv}C - CH_3 + 2CH_2N_2 \xrightarrow{\Delta}$ 

10. In any group second period element exhibit anomalous properties. Correct statements about this is/are

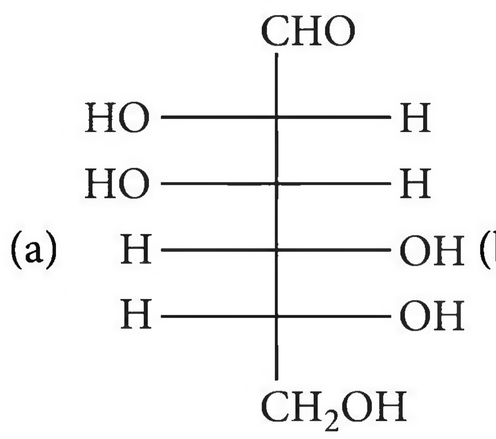
(a) generally maximum covalence of the first member of each group cannot exceed four

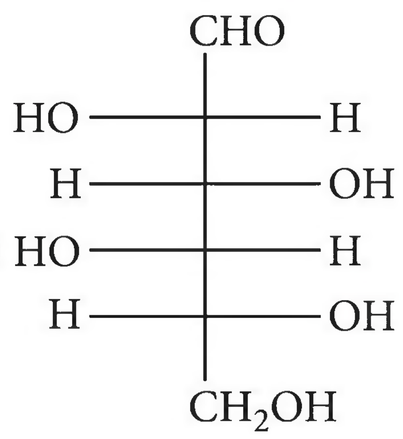
(b) the first member of *p*-block element displays greater ability to form $p\pi - d\pi$ multiple bonds to itself and to the other second period elements, compared to subsequent members of the group

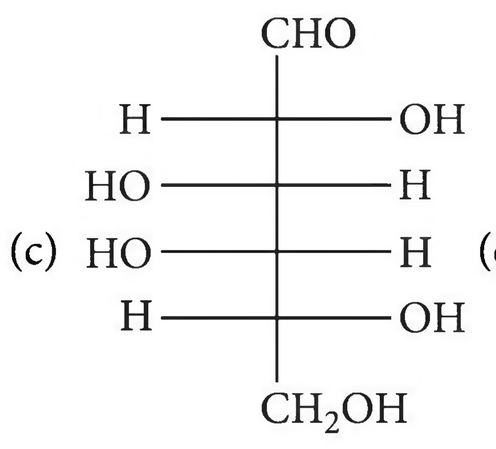
(c) anomalous behaviour is due to small size, large charge/radius ratio and high electronegativity of the elements

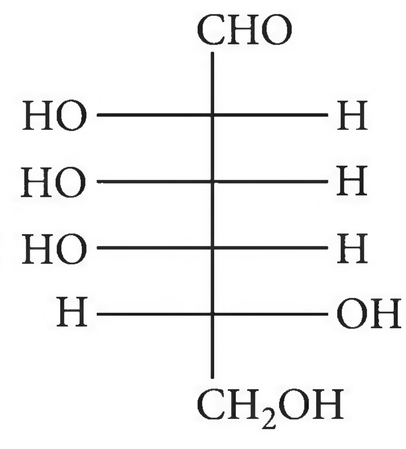
(d) all second period elements exhibit diagonal relationship.

11. Which of the following monosaccharides yield(s) an optically active aLditol on $NaBH_4$ reduction?

(a) 

(b) 

(c) 

(d) 

12. The reaction of propene with HOCl proceeds *via* the addition of

(a) H^+ in the first step (b) Cl^+ in the first step

(c) OH^- in the first step

(d) Cl^+ and OH^- in a single step.

Section 3 (Maximum Marks : 24)

- ***This section contains SIX (06) questions. The answer to each question is a NUMERICAL VALUE.***
- ***For each question, enter the correct numerical value of the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer. If the numerical value has more than two decimal places, truncate/round-off the value to TWO decimal places.***
- ***Answer to each question will be evaluated according to the following marking scheme :***

Full Marks :	***+4***	***If ONLY the correct numerical value is entered.***
Zero Marks :	***0***	***In all other cases.***

13. The velocity constant of the decomposition of hydrogen iodide at 283°C and 508°C are 3.517×10^{-7} and 3.954×10^{-2} respectively. Calculate the frequency factor of reaction at 283°C.

14. 1 mole of an ideal gas $A(C_{v,m} = 3R)$ and 2 mole of an ideal gas B are $\left(C_{v,m} = \frac{3}{2}R\right)$ taken in a container and expanded reversible and adiabatically from 1 litre to 4 litre starting from initial temperature of 320 K. ΔE or ΔU (in Joules) for the process is _____.

15. A certain dye absorbs light of $\lambda = 4530$ Å and then fluorescence light of 5080 Å. Assuming that under given conditions 47% of the absorbed energy is re-emitted out as fluorescence, calculate the ratio of quanta emitted out to the no. of quanta absorbed.

16. 1.0 g of a mixture of carbonates of calcium and magnesium gave 240 mL of CO_2 of N.T.P. Calculate the percentage composition of $MgCO_3$.

17. The resistance of a solution A is 50 ohm and that of solution B is 100 ohm, both solution being taken in the same conductivity cell. If equal volumes of solutions A and B are mixed, what will be the resistance of the mixture using the same cell? (Assuming that there is no increase in the degree of dissociation of A and B on mixing).

18. How much of 0.3 M ammonium hydroxide should be mixed with 30 mL of 0.2 M solution of ammonium chloride to give buffer solution of pH 8.65 ($pK_b = 4.75$)?

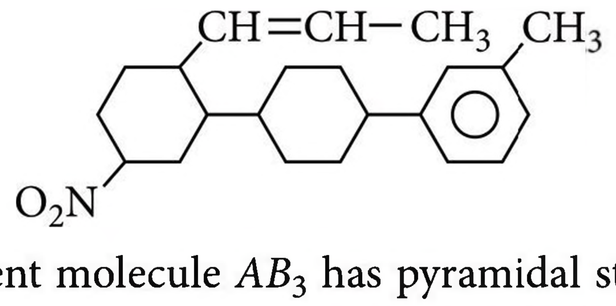
PAPER - II

Section 1 (Maximum Marks : 18)

- ***This section contains SIX (06) questions.***
- ***The answer to each question is a SINGLE DIGIT INTEGER ranging from 0 to 9, BOTH INCLUSIVE.***
- ***For each question, enter the correct integer corresponding to the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.***
- ***Answer to each question will be evaluated according to the following marking scheme :***

Full Marks :	***+3***	***If ONLY the correct integer is entered.***
Zero Marks :	***0***	***If the question is unanswered;***
Negative Marks :	***–1***	***In all other cases.***

1. The number of stereocentres present in the given compound is



2. A covalent molecule AB_3 has pyramidal structure. The sum of numbers of lone pair and bond pair electrons in the molecule is

3. Grams of potassium dichromate required to oxidise 24.82 g of Fe^{2+} in $FeSO_4$ to Fe^{3+}, if the reaction is carried out in an acidic solution is
[At. wt. K = 39 u, Cr = 52 u, Fe = 56 u, S = 32 u, O = 16 u]

4. The dissociation energy of H_2 is 430.53 kJ/mol. If H_2 is exposed to light energy of wavelength 253.7 nm, percentage of light energy converted to kinetic energy is

5. The number of nodal planes present in σ^*s antibonding orbitals is

6. The maximum number of carbon atoms arranged linearly in the following molecule is

$H_3C - C \equiv C - CH_2 - CH_3$

Section 2 (Maximum Marks : 24)

- ***This section contains SIX (06) questions.***
- ***Each question has FOUR options. ONE OR MORE THAN ONE of these four option(s) is (are) correct answer(s).***
- ***For each question, choose the option(s) corresponding to (all) the correct answer(s).***
- ***Answer to each will be evaluated according to the following marking scheme :***

Full Marks : +4 *If only (all) the correct option(s) is (are) chosen;*

Partial Marks : +3 *If all the four options are correct but ONLY three options are chosen;*

Partial Marks : +2 *If three or more options are correct but ONLY two options are chosen, and both of which are correct;*

Partial Marks : +1 *If two or more options are correct but ONLY one option is chosen and it is a correct option;*

Zero Marks : 0 *If none of the options is chosen (i.e., the question is unanswered);*

Negative Marks : –2 *In all other cases.*

7. The pairs of compounds which cannot exist together in aqueous solution are

(a) NaH_2PO_4 and Na_2HPO_4

(b) Na_2CO_3 and $NaHCO_3$

(c) NaOH and NaH_2PO_4

(d) $NaHCO_3$ and NaOH

8. In which of the following cases ($E_{cell} - E°_{cell}$) is zero?

(a) $Cu|Cu^{2+}(0.01\ M)||\ Ag^{+}\ (0.1\ M)|Ag$

(b) $Pt(H_2)|pH = 1||Zn^{2+}\ (0.01\ M)|\ Zn$

(c) $Pt(H_2)|pH = 1||Zn^{2+}\ (1\ M)|Zn$

(d) $Pt\ (H_2)|H^{+}\ (0.01\ M)||Zn^{2+}\ (0.01\ M)|\ Zn$

9. Devise a series of reactions to convert ethyl 3-oxobutanoate to ethyl 4-oxopentanoate.

Select reagents and conditions from the following table, listing them in the order of use :

(1) Sodium ethoxide in ethanol

(2) Ethanol + Acid catalyst

(3) H_3O^{+}; heat

(4) CO_2; then H_3O^{+}

(5) Mg in ether

(6) PBr_3

(7) $NaBH_4$ in alcohol

(8) CH_2I_2 in ether; Zn – Cu

(9) $BrCH_2COOC_2H_5$

(10) $(CH_3CO)_2O$; Pyridine

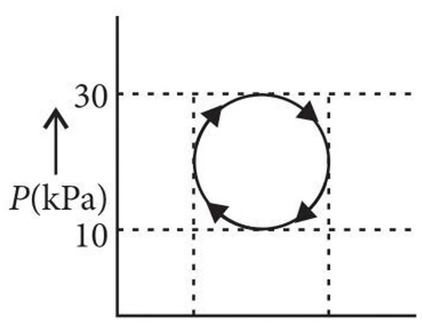
(a) 1, 9, 3, then 2

(b) 7, 6, 5, 10, then 2

(c) 3, 7, 6, 5, 10, then 2

(d) 8, 3, then 2

10. Which of the following is/are correct for a cyclic process as shown in the figure?



(a) $dU = 0$

(b) $q = -w$

(c) $w = 314$ J

(d) $w = 31.4$ J

11. (Ag + Pb) alloy $\xrightarrow[\text{is added}]{\text{melt and zinc}}$ (Ag + Pb + Zn) melt $\xrightarrow{\text{cool}}$ $\frac{\text{Layer X}}{\text{Layer Y}}$

Select the correct statement based on the above scheme :

(a) Layer *X* contains zinc and silver.

(b) Layer *Y* contains lead and silver but amount of silver in this layer is smaller than in the layer *X*.

(c) *X* and *Y* are immiscible layers.

(d) All are correct statements.

12. Extraction of metal from the ore cassiterite involves

(a) carbon reduction of an oxide ore

(b) self-reduction of a sulphide ore

(c) removal of copper impurity

(d) removal of iron impurity.

Section 3 (Maximum Marks : 24)

- *This section contains SIX (06) questions. The answer to each question is a NUMERICAL VALUE.*
- *For each question, enter the correct numerical value of the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer. If the numerical value has more than two decimal places, truncate/round-off the value to TWO decimal places.*
- *Answer to each question will be evaluated according to the following marking scheme :*

Full Marks : +4 *If ONLY the correct numerical value is entered;*

Zero Marks : 0 *In all other cases.*

13. A solution is prepared by mixing 8.5 g of CH_2Cl_2 and 11.95 g of $CHCl_3$. If vapour pressure of CH_2Cl_2 and $CHCl_3$ at 298 K are 415 and 200 mmHg respectively, the mole fraction of $CHCl_3$ in vapour form is: (Molar mass of Cl = 35.5 g mol^{-1}).

14. A solution contains 0.05 M of Ba^{2+} ions and 0.002 M of Ag^{+} ions. The metals are to be precipitated by adding of chromate ions. What percentage of ion that precipitate first will remain in the solution when second ion begins to precipitate?

(K_{sp} of $Ag_2CrO_4 = 3 \times 10^{-12}$, K_{sp} of $BaCrO_4 = 1 \times 10^{-10}$)

15. The gases produced when 18 g carbon reacts with 5 litre of oxygen at 18°C and 5 atm pressure, are treated with 0.5 litre of 2 M NaOH. The concentration of sodium bicarbonate produced by the reaction of CO_2 with NaOH is _____. (Assume CO has no reaction under these conditions.)

16. Periodic acid splits glucose and fructose into formaldehyde and formic acid. Ratio of moles of formic acid in glucose and fructose is $x : y$. Then $x + y$ is _____.

17. Calculate the amount of polythene formed from 20 kg of calcium carbide from the reactions given below :

$$CaC_2 + 2H_2O \longrightarrow Ca(OH)_2 + C_2H_2$$

$$HC{\equiv}CH + H_2 \xrightarrow{Pd\text{–}BaSO_4} CH_2{=}CH_2$$

$$nCH_2{=}CH_2 \longrightarrow \underset{\text{Polythene}}{+CH_2-CH_2+_n}$$

18. Ionic solid Na^+A^- crystallise in rock salt type structure. 2.592 g of ionic solid salt NaA dissolved in water to make 2 L solution. The pH of this solution is 8.5. If distance between cation and anion is 300 pm, the density of ionic solid (in g/cm^3) is _____.
(Given : pK_w = 14, pK_a(HA) = 5, $N_A = 6 \times 10^{23}$)

SOLUTIONS

PAPER - I

1. (d): $\sqrt{\frac{8RT}{\pi M_A}} = \sqrt{\frac{3RT}{M_B}}$

$$\frac{8}{\pi M_A} = \frac{3}{M_B} \Rightarrow \frac{M_A}{M_B} = \frac{8}{3\pi}$$

for $\sqrt{\frac{8RT}{\pi M_A}} = \sqrt{\frac{8RT'}{\pi M_B}}$

$$\frac{T}{M_A} = \frac{T'}{M_B}; \quad \frac{3\pi T}{8M_B} = \frac{T'}{M_B}$$

$$\frac{T}{T'} = \frac{8}{3\pi} \qquad T' > T$$

2. (a): Oxidation state of C in CO_3^{2-} is +4, which is maximum. So, it will not be oxidised.

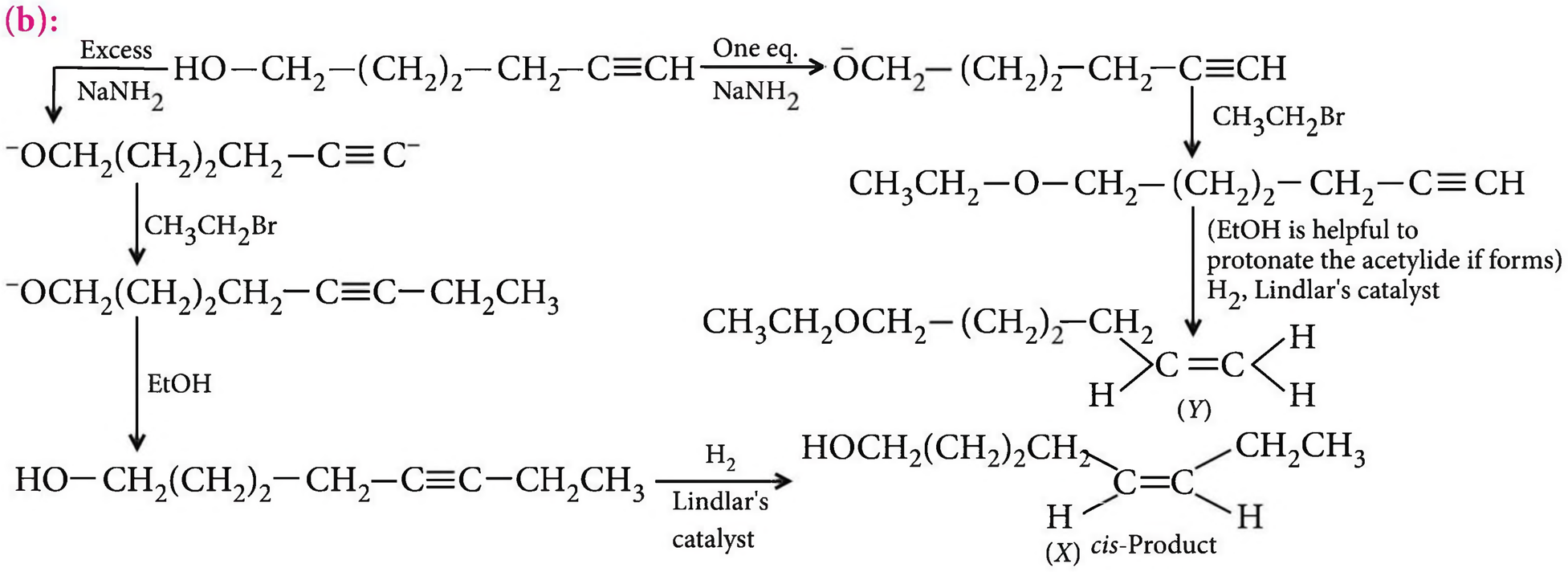
3. (b): In BCl_3, the state of hybridisation,

$$H = \frac{1}{2}(3 + 3 + 0 - 0) = 3 \textit{ i.e., } sp^2$$

So, the bond angle is 120°.
The state of hybridisation in case of P, As and Bi is sp^3 and due to the presence of a lone pair on the central atom the bond angle is less than normal tetrahedral angle of 109°28′, *i.e.*, bond angle < 109°28′. Since the central atom (P, As, Bi) belong to the same group, the bond angle of ECl_3 decreases as we go down the group, *i.e.*, from P to As to Bi, thus the correct order of bond angles is $BCl_3 > PCl_3 > AsCl_3 > BiCl_3$.

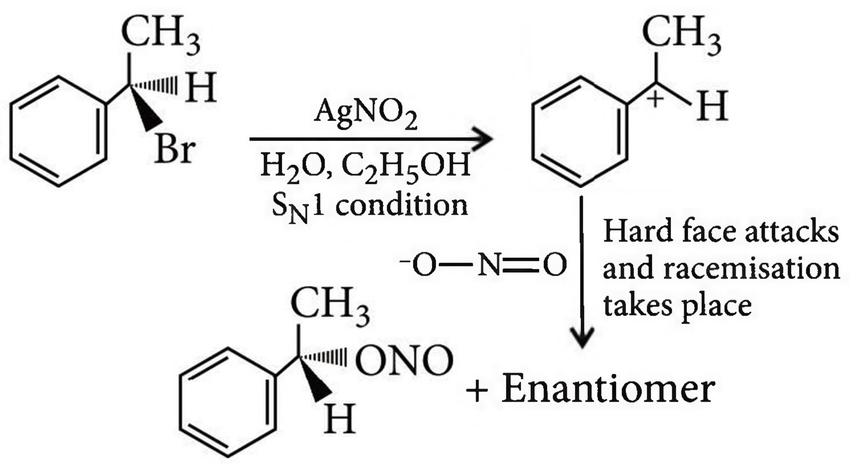
4. (a): K_p does not change significantly with pressure.

5. (b):

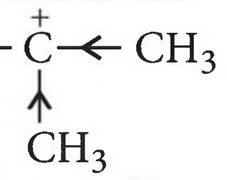


6. (d)

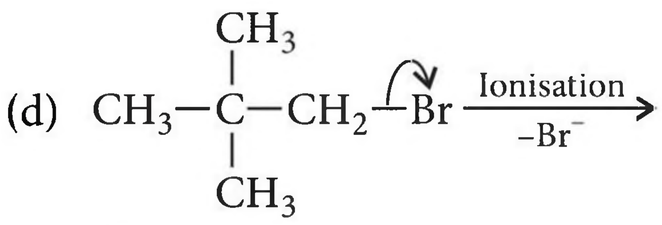
7. (c) :



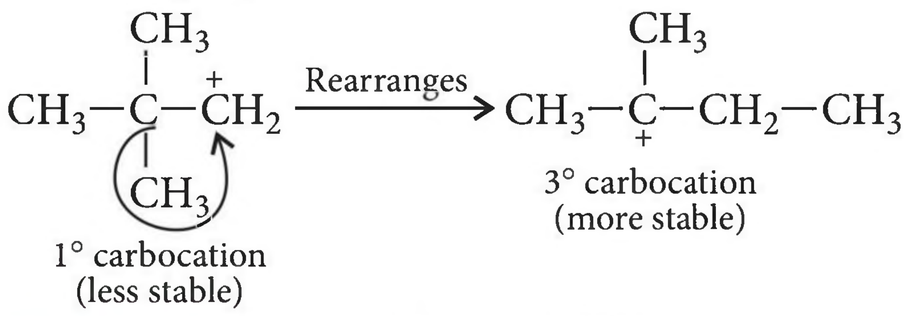
8. (a, b, c, d) : All form stable carbocations therefore, all options are correct.
(a) $C_6H_5C^+H_2$ is stabilised by resonance over the phenyl ring.
(b) $CH_2{=}CH{-}\overset{+}{C}H_2 \longleftrightarrow \overset{+}{C}H_2{-}CH{=}CH_2$ is also stabilised by resonance.
(c)



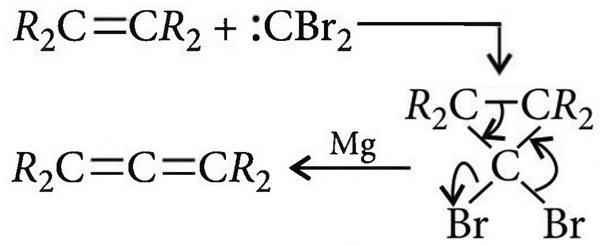
is stabilised by +I-effect of –CH_3 groups.

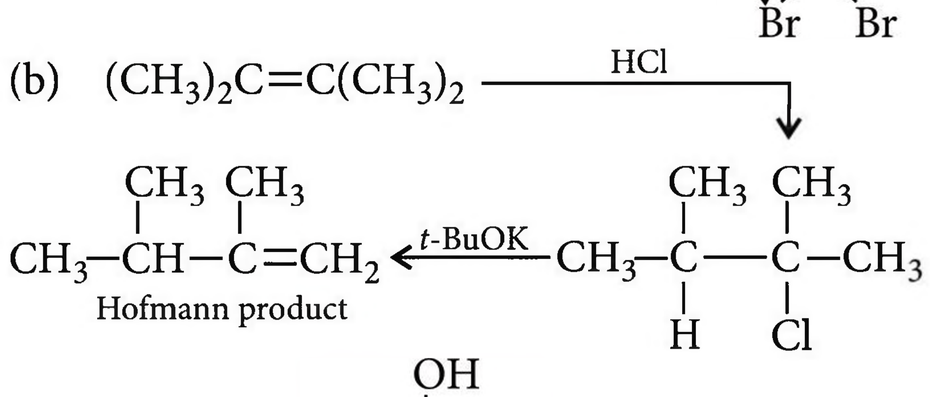
(d) 

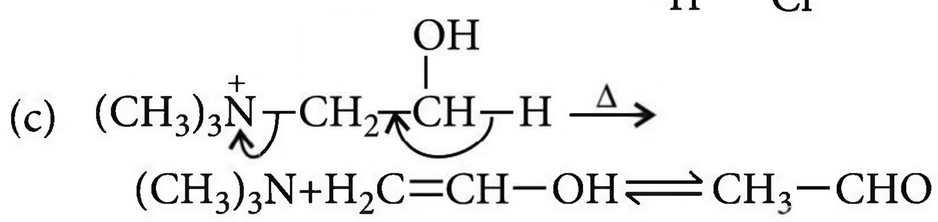
Neopentyl bromide

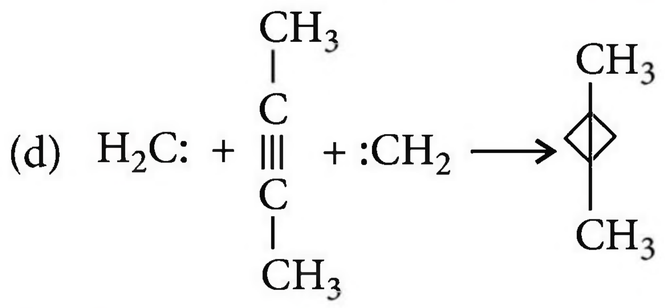


1° carbocation
(less stable)

9. (a, b, c, d) : (a) 

(b) 

(c) 

(d) 

10. (a,c): Due to the absence of *d*-subshell in valence shell, second period element do not exhibit maximum covalence beyond 4. 2nd period elements form strong $p\pi - p\pi$ bonds not $p\pi - d\pi$ bonds. Anomalous behaviour is due to small size, high electronegativity. Diagonal relationship exist only up to IV group.

11. (a, b, d) : Only the alditol (monosaccharide having $-CH_2OH$ at both ends) from structure (c) has a plane of symmetry hence, it will be optically inactive. The other three form optically active alditols.

12. (b): Alkenes undergo electrophilic addition reactions. HOCl on self-ionisation produces Cl^+ which attacks first.

$HOCl + HOCl \longrightarrow H_2O + OCl^- + Cl^+$

13. (8.359×10^{33}) : We know that,

$$E_a = \frac{2.303 \times R \times T_1 \times T_2}{T_1 - T_2} \log \frac{k_2}{k_1}$$

$$= \frac{2.303 \times 2 \times 556 \times 781}{781 - 556} \log \frac{3.954 \times 10^{-2}}{3.517 \times 10^{-7}}$$

By usual calculations, $E_a = 44898$ cal

We now that $k = Ae^{-E_a/RT}$

Substituting the values of k, E_a, R and T

$3.517 \times 10^{-7} = A.e^{-44898/2 \times 556}$

$$\log 3.517 \times 10^{-7} = \log A - \frac{44898}{2 \times 556}$$

$\log A = -6.4538 + 40.376$

$A = 8.359 \times 10^{33}$.

14. (–7981.44) : $C_{v,m} = \dfrac{n_1 C_{v,m_1} + n_2 C_{v,m_2}}{n_1 + n_2} = 2\ R$

For adiabatic process, $dU = dW$

$$\frac{dT}{T} = -\frac{R}{C_{v,m}}\left(\frac{dV}{V}\right)$$

$$n_1 C_{v,m_1} dT + n_2 C_{v,m_2} dT = -(n_1 RT + n_2 RT) \times \frac{dV}{V}$$

$$\ln \frac{T_2}{T_1} = -\frac{1}{2} \ln \left(\frac{V_2}{V_1}\right) \quad \Rightarrow \quad T_2 = 320 \times \left(\frac{1}{4}\right)^{1/2}$$

= 160 K

$\Delta U = (n_1 C_{v,m_1} + n_2 C_{v,m_2}) \Delta T = -960\ R$

= – 960 × 8.314 = – 7981.44 J

15. (0.527) : E of light absorbed in one photon

$$= \frac{hc}{\lambda_{absorbed}}$$

Let n_1 photons are absorbed, therefore,

Total energy absorbed = $\dfrac{n_1 hc}{\lambda_{absorbed}}$

Now, E of light re-emitted out in one photon

$$= \frac{hc}{\lambda_{emitted}}$$

Let n_2 photons are re-emitted then,

Total energy re-emitted out = $n_2 \times \dfrac{hc}{\lambda_{emitted}}$

As given, $E_{absorbed} \times \dfrac{47}{100} = E_{re\text{-}emitted}$

$$\frac{hc}{\lambda_{absorbed}} \times n_1 \times \frac{47}{100} = n_2 \times \frac{hc}{\lambda_{emitted}}$$

$$\therefore \quad \frac{n_2}{n_1} = \frac{47}{100} \times \frac{\lambda_{emitted}}{\lambda_{absorbed}} = \frac{47}{100} \times \frac{5080}{4530}$$

$$\therefore \quad \frac{n_2}{n_1} = 0.527$$

16. (37.5) : $CaCO_3 \longrightarrow \underset{100\text{ g}}{CaO} + \underset{22400\text{ mL}}{CO_2}$

$MgCO_3 \longrightarrow \underset{100\text{ g}}{MgO} + \underset{22400\text{ mL}}{CO_2}$

Let $CaCO_3$ present in the mixture = x g

Now 100 g of $CaCO_3$ give CO_2 = 22400 mL

x g of $CaCO_3$ will give $CO_2 = \dfrac{22400 \times x}{100} = 224 \times$ g

Similarly, 84 g of $MgCO_3$ give CO_2 = 22400 mL

$(1 - x)$ g of $MgCO_3$ give $CO_2 = \dfrac{22400 \times (1-x)}{84}$

$= 226.7\ (1 - x)$

Total CO_2 evolved at N.T.P = 240 mL

Now, $224x + 266.7\ (1 - x) = 240$

$224x + 226.7x = 40$

$-42.7\ x = -26.7$

$x = \dfrac{26.7}{42.7} = 0.625$

Wt. of $CaCO_3$ = 0.625 g

Wt. of $MgCO_3$ = 0.375 g

$\%\ CaCO_3 = \dfrac{0.625}{1} \times 100 = 62.5$

$\%\ MgCO_3 = \dfrac{0.375 \times 100}{1} = 37.5$

17. (66.67) : Let κ_1 and κ_2 be the specific conductance of the solution *A* and *B* respectively and the cell constant of the cell be *X*. For solution *A* : Specific conductance = Conductance × Cell constant

$$\kappa_1 = \frac{1}{50} \times X \qquad ...(i)$$

For solution *B* : Specific conductance

$$\kappa_2 = \frac{1}{100} \times X \qquad ...(ii)$$

When equal volumes of *A* and *B* are mixed, both the solutions get double diluted, hence their individual contribution towards the sp. conductance of the mixture will be $\dfrac{\kappa_1}{2}$ and $\dfrac{\kappa_2}{2}$ respectively and the sp. conductance of the mixture will be $\dfrac{1}{2}(\kappa_1 + \kappa_2)$

$\therefore$ For the mixture $\dfrac{1}{2}(\kappa_1 + \kappa_2) = \dfrac{1}{R} \times X \qquad ...(iii)$

$\dfrac{1}{4}$ *R* is the resistance of mixture $\dfrac{1}{2}$

From eq. (i), (ii) and (iii), *R* = 66.67 ohm.

18. (5.02) : For basic butter solution:

$$pH = 14 - pK_b + \log\frac{[Base]}{[Salt]}$$

$$pH = 14 - 4.75 + \log\frac{[Base]}{[Salt]}$$

$$\text{or } \log\frac{[Base]}{[Salt]} = pH - 9.25$$

For buffer of pH = 8.65

$$\log\frac{[Base]}{[Salt]} = 8.65 - 9.25$$

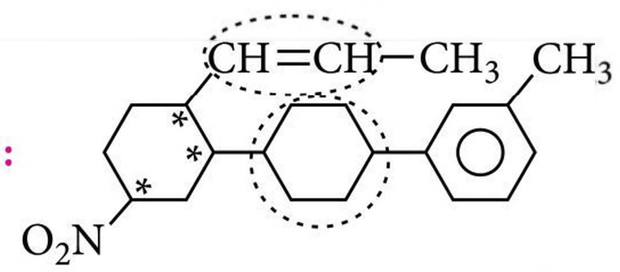
$$\text{or } \frac{[Base]}{[Salt]} = \text{Antilog}(0.60) = 0.25$$

$$\text{or } \frac{[NH_4OH]}{[NH_4Cl]} = \frac{\frac{0.3 \times V}{1000}}{\frac{0.2 \times 30}{1000}} = 0.25$$

$$V = \frac{0.25 + 0.2 \times 30 \times 1000}{0.3 \times 1000} = 5.02 \text{ mL}$$

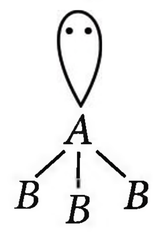
PAPER - II

1. (5) :



Asterisk carbons represent chiral carbons which will show optical isomerism while carbons in the dotted region will show geometrical isomerism.

2. (4) : In general, a compound with formula AB_3 is sp^2-hybridised with triangular planar geometry. However, the given compound has pyramidal structure which is possible only when it has a lone pair of electrons. Thus, AB_3 has three bond pairs and one lone pair.



Sum = 3 + 1 = 4

3. (8) : When dissolved in water, $K_2Cr_2O_7$ dissociates into K^+ and $Cr_2O_7^{2-}$ ions and $FeSO_4$ dissociates into Fe^{2+} and SO_4^{2-} ions. The skeleton equation is :

$Fe^{2+} + Cr_2O_7^{2-} \rightarrow Fe^{3+} + 2Cr^{3+}$

The balanced chemical equation is

$Cr_2O_7^{2-} + 6Fe^{2+} + 14H^+ \rightarrow 6Fe^{3+} + 2Cr^{3+} + 7H_2O$

From the balanced chemical equation, it is clear that

1 mol $K_2Cr_2O_7 \equiv$ 6 mol $FeSO_4$

Formula weight of $K_2Cr_2O_7 = 2 \times 39 + 2 \times 52 + 7 \times 16$

$= 294$ g mol^{-1}

Formula weight of $FeSO_4$ = 152 g mol^{-1}

1 mol $K_2Cr_2O_7 \equiv 6$ mol $FeSO_4$

$1 \times 294 \qquad 6 \times 152$

6×152 g $FeSO_4$ require $K_2Cr_2O_7 = 294$ g

24.82 g of $FeSO_4$ will require $K_2Cr_2O_7$

$$= \frac{294}{6 \times 152} \times 24.82 \text{ g} = 8 \text{ g}$$

4. (9): Energy associated with H_2 molecule corresponding to wavelength 253.7 nm $= \frac{hc}{\lambda}$

$$= \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{253.7 \times 10^{-9}} = 7.84 \times 10^{-19} \text{ J}$$

$= 7.84 \times 10^{-19} \times 6.02 \times 10^{23}$ J/mol

$= 472 \times 10^{3}$ J/mol

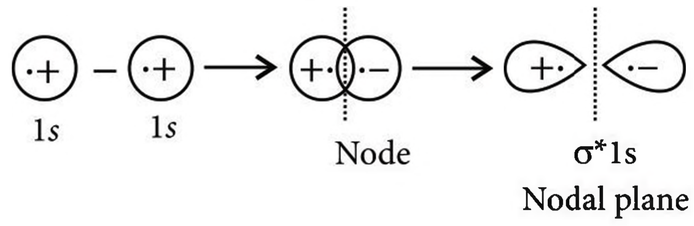
% of light energy consumed

$$= \frac{430.53 \times 10^{3}}{472 \times 10^{3}} \times 100 = 91.2\%$$

Fraction of light energy converted into K.E.

$= 8.8\ \% \approx 9\%$

5. (1): The molecular orbital σ^*s is formed by the subtractive overlapping of two *s*-orbitals.



6. (4): *sp*-hybridised carbon atoms as well as carbon atoms directly attached to it are linearly arranged.

$$\overset{sp}{H_3C} - \overset{sp}{C} \equiv C - CH_2 - CH_3$$

So, total number = 4

7. (c,d) : NaOH is a strong base whereas NaH_2PO_4 is a salt of strong base (NaOH) and weak acid (H_3PO_4). Hence, NaOH and NaH_2PO_4 do not exist together in aqueous solution. NaOH is a strong base, whereas $NaHCO_3$ is a salt of strong base (NaOH) and weak acid (H_2CO_3). Hence NaOH and Na_2CO_3 do not exist together.

8. (a, b) : (a) $E_{cell} = E^{\circ}_{cell} - \frac{2.303RT}{2F} \log \frac{[Cu^{2+}]}{[Ag^{+}]^2}$

$$E_{cell} - E^{\circ}_{cell} = -\frac{2.303RT}{2F} \log \frac{0.01}{(0.1)^2}$$

$E_{cell} - E^{\circ}_{cell} = 0$

(b) $$E_{cell} - E^{\circ}_{cell} = -\frac{2.303RT}{2F} \log \frac{[H^{+}]^2}{[Zn^{2+}]}$$

$$= -\frac{2.303RT}{2F} \log \frac{(1 \times 10^{-1})^2}{(0.01)} = 0$$

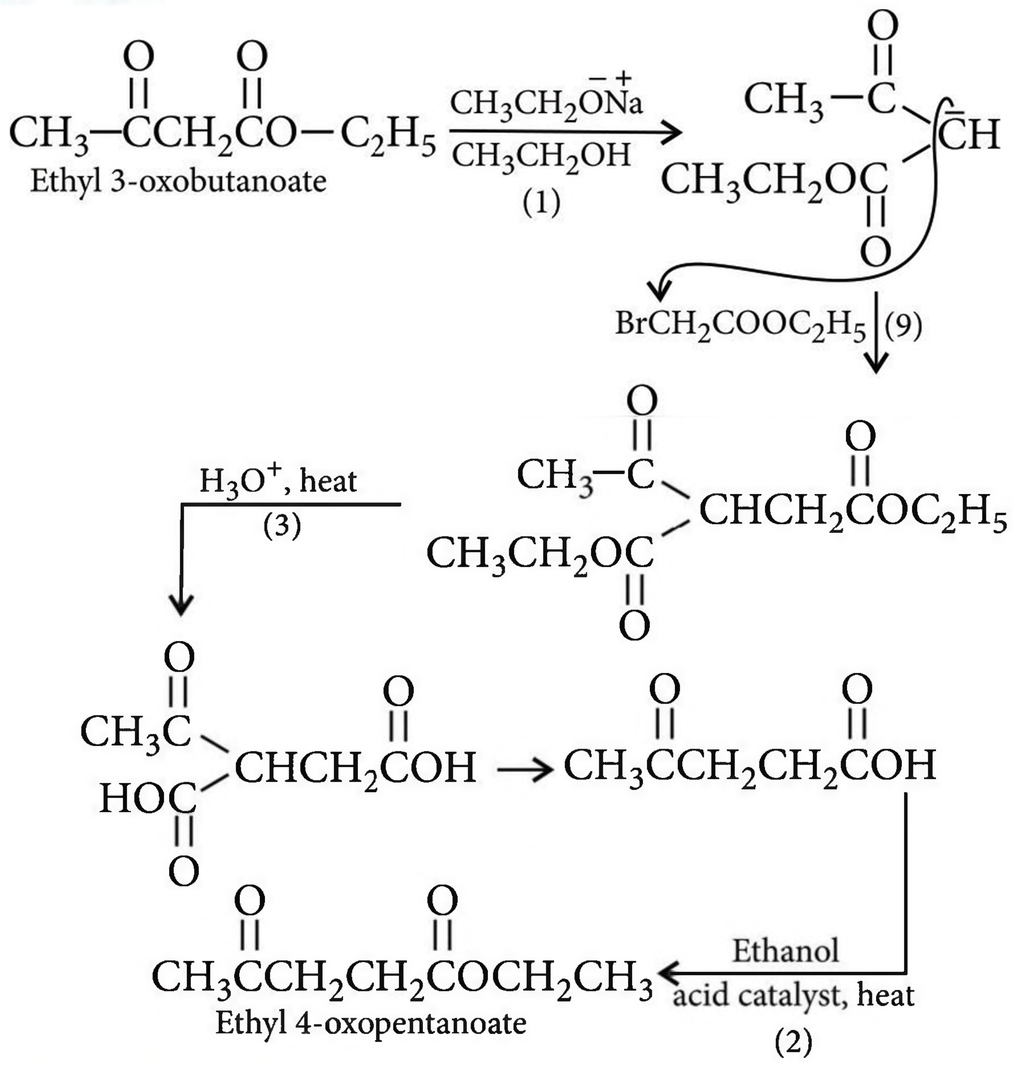
(c) $$E_{cell} - E^{\circ}_{cell} = -\frac{2.303RT}{2F} \log \frac{[H^{+}]^2}{[Zn^{2+}]}$$

$$= -\frac{2.303RT}{2F} \log \frac{(1 \times 10^{-1})^2}{1} \neq 0$$

(d) $$E_{cell} - E^{\circ}_{cell} = -\frac{2.303RT}{2F} \log \frac{[H^{+}]^2}{[Zn^{2+}]}$$

$$= -\frac{2.303RT}{2F} \log \frac{(0.01)^2}{(0.01)} \neq 0$$

9. (a) :



10. (a, b, c) : For a cyclic process, $dU = 0$

$\therefore \quad q = dU + (-w) \Rightarrow q = -w$

Also, w = Area covered by the curve

$$= \pi r^2 = \pi \times \left[\frac{(V_2 - V_1)}{2}\right]^2 = \frac{\pi \times (20)^2}{2^2}$$

$= 100\ \pi = 100 \times 3.14 = 314$ J

11. (d): Zinc and lead in molten state are immiscible and form separate layers, zinc being lighter forms upper layer. Ag is soluble in both.

12. (a, c, d) : Tin is extracted from cassiterite ore.

It is reduced by carbon.

$SnO_2 + 2C \longrightarrow Sn + 2CO$

Crude metal contains impurities Fe, W and Cu.

13. (0.325) : Molar mass of $CHCl_3 = 119.5$ g/mol

Molar mass of $CH_2Cl_2 = 85$ g/mol

Moles of $CHCl_3 = \frac{11.95}{119.5} = 0.1$ mol

Moles of $CH_2Cl_2 = \frac{8.5}{8.5} = 0.1$ mol

Mole of fraction of $CHCl_3 = \frac{0.1}{0.2} = 0.5$ mol.

Mole of fraction $CH_2Cl_2 = \frac{0.1}{0.2} = 0.5$ mol.

(Given -

Vapour pressure of $CHCl_3 = 200$ mm Hg $= 0.263$ atm.

Vapour pressure of $CH_2Cl_2 = 415$ mm Hg $= 0.546$ atm)

(1 atm = 760 mm Hg)

$\therefore \quad P_{\text{(above solution)}}$

= Mole fraction of $CHCl_3 \times$ (Vapour pressure of $CHCl_3$

+ Mole fraction of $CH_2Cl_2 \times$ (Vapour pressure of CH_2Cl_2)

$= 0.5 \times 0.263 + 0.5 \times 0.546 = 0.4045$

Mole fraction of $CHCl_2$ in vapour form

$= \frac{0.1315}{0.4045} = 0.325.$

14. (0.26) : $[CrO_4^{2-}]$ required to precipitate $BaCrO_4$

$= \frac{K_{sp} \text{ of } BaCrO_4}{[Ba^{2+}]} = \frac{1\times10^{-10}}{0.05} = 2\times10^{-9}$ M

$[CrO_4^{2-}]$ required to precipitate Ag_2CrO_4

$= \frac{K_{sp} \text{ of } Ag_2CrO_4}{[Ag^+]^2} = \frac{3\times10^{-12}}{(2\times10^{-3})^2} = 7.5\times10^{-7}$ M

Ba^{2+} ions require low concentration of CrO_4^{2-} ions for precipitation. So, Ba^{2+} ion will precipitate first. When Ag^+ ions start precipitating as Ag_2CrO_4, the concentration of CrO_4^{2-} ion will be 7.5×10^{-7} M

$[Ba^{2+}]_{\text{remaining in solution}}$

$= \frac{K_{sp} \text{ of } BaCrO_4}{[CrO_4^{2-}]} = \frac{1\times10^{-10}}{7.5\times10^{-7}} = 1.33 \times 10^{-4}$ M

% of Ba^{2+} remaining in solution

$= \frac{1.33\times10^{-4}}{0.05} \times 100 = 0.26\%$

15. (0.368) : $C + \frac{1}{2}O_2 \longrightarrow CO$ ...(i)

$C + O_2 \longrightarrow CO_2$ ...(ii)

Let a mole of C reacts according to eq. (i) and b mole of C reacts according to eq. (ii)

Then, $a + b = \frac{18}{12} = 1.5$ ...(iii)

Also, mole of O_2 used $= \frac{a}{2} + b = \frac{5\times5}{0.0821\times291}$ $\left(n = \frac{PV}{RT}\right)$

or, $\frac{a}{2} + b = 1.046$ ...(iv)

By eqs. (iii) and (iv), $a = 0.908$; $b = 0.592$

Thus, CO_2 formed = 0.592 mole

mmol of NaOH given = 2 × 500 = 1000

mmol of CO_2 formed = 592

Now, the reaction of CO_2 with NaOH will occur as:

$2NaOH + CO_2 = Na_2CO_3 + H_2O$

mmol before reaction	1000	592	0
mmol after reaction	0	92	500

$Na_2CO_3 + CO_2 + H_2O = 2NaHCO_3$

mmol before reaction	500	92	0
mmol after reaction	408	0	2 × 92 = 184

$M_{NaHCO_3} = \frac{184}{500} = 0.368$ M

16. (8) : $(CHOH)_4$ (CHO, CH_2OH — glucose) $\xrightarrow{5HIO_4}$ $5HCOOH + HCHO + 5HIO_3$

CH_2OH

$C=O$

$(CHOH)_3$ (fructose) $\xrightarrow{5HIO_4}$ $3HCOOH + 2HCHO + 5HIO_3 + CO_2 + H_2O$

CH_2OH

$\therefore$ Molar ratio (x : y) is 5 : 3. So, $x + y = 5 + 3 = 8$

17. (8.75) : Molecular mass of $CaC_2 = 40 + 24 = 64$

64 kg of CaC_2 gives = 28 kg of ethene

20 kg of CaC_2 will give = $\frac{28}{64} \times 20 = 8.75$ kg

18. (4) : NaA is salt of strong base and weak acid.

$pH = \frac{pK_w}{2} + \frac{1}{2}(pK_a + \log C)$

$8.5 = 7 + \frac{1}{2}(5 + \log C)$; $1.5 \times 2 = 5 + \log C$

$\log C = -2$

$C = 0.01 = \frac{2.592}{M\times2} \Rightarrow M = \frac{2.592}{2\times0.01} = 129.6$

$d = \frac{ZM}{N_A a^3}$, ($Z = 4$, $a = 2 \times 300 = 600$ pm)

$\Rightarrow d = 4$ g/cm^3

30 MIND BLOWING PROBLEMS

OLYMPIAD CORNER

OBJECTIVE PROBLEMS

1. A galvanic cell is composed of two hydrogen electrodes, one of which is a standard one. In which of the following solutions should the other electrode be immersed to get maximum e.m.f.?

(a) 0.1 M HCl (b) 0.1 M CH_3COOH

(c) 0.1 M H_3PO_4 (d) 0.1 M H_2SO_4

2. Consider oxidation of following compounds :

I. $CH_2{=}CHCH_2OH \xrightarrow{A} CH_2{=}CHCHO$

II. $(CH_3)_3COH \xrightarrow{B} CH_3\underset{\displaystyle CH_3}{\overset{\displaystyle |}{C}}{=}CH_2$

III. $CH_3CH_2OH \xrightarrow{C} CH_3COOH$

IV. $CH_3CH{=}CHCH_3 \xrightarrow{D} CH_3COOH$

A, *B*, *C* and *D* are oxidising agents which are respectively

	A	***B***	***C***	***D***
(a)	MnO_2	Cu/Δ	H_2CrO_4	$KMnO_4/\Delta$
(b)	Cu/Δ	MnO_2	H_2CrO_4	$KMnO_4/\Delta$
(c)	MnO_2	Cu/Δ	$KMnO_4/\Delta$	H_2CrO_4
(d)	MnO_2	H_2CrO_4	Cu/Δ	$KMnO_4/\Delta$

3. Which is not correctly matched?

(1) Basic strength of oxides : $Cs_2O < Rb_2O < K_2O < Na_2O < Li_2O$

(2) Stability of peroxides : $Na_2O_2 < K_2O_2 < Rb_2O_2 < Cs_2O_2$

(3) Stability of bicarbonates : $LiHCO_3 < NaHCO_3 < KHCO_3 < RbHCO_3 < CsHCO_3$

(4) Melting point : NaF < NaCl < NaBr < NaI

(a) 1 and 4 (b) 1 and 3

(c) 1 and 2 (d) 2 and 3

4. For the reaction $2A \longrightarrow B + 3C$; if

$$-\frac{d[A]}{dt} = k_1[A]^2; \frac{d[B]}{dt} = k_2[A]^2; \frac{d[C]}{dt} = k_3[A]^2$$

the correct relation between k_1, k_2, and k_3 is

(a) $k_1 = k_2 = k_3$ (b) $2k_1 = k_2 = 3k_3$

(c) $4k_1 = k_2 = 3k_3$ (d) $\frac{k_1}{2} = k_2 = \frac{k_3}{3}$

5. A yellow solid known to be a single compound is completely insoluble in hot water but dissolves in hot dilute HCl to give an orange solution. When this solution is cooled, a white crystalline ppt. is formed. This white ppt. redissolves on heating the solution. The compound is

(a) $Fe(OH)_3$ (b) $PbCrO_4$

(c) K_2CrO_4 (d) $Co(OH)_2$

6. Aluminium chloride exists as dimer, Al_2Cl_6 in solid state as well as in solution of non-polar solvents such as benzene. When dissolved in water, it gives

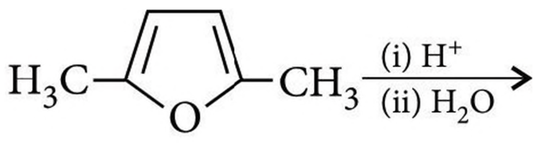
(a) $Al^{3+} + Cl^-$

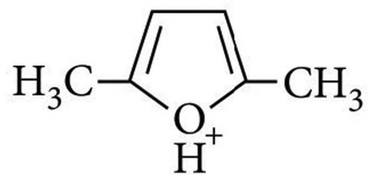
(b) $[Al(H_2O)_6]^{3+} + Cl^-$

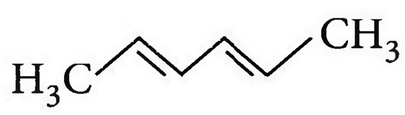
(c) $[Al(OH)_6]^{3-} + HCl$

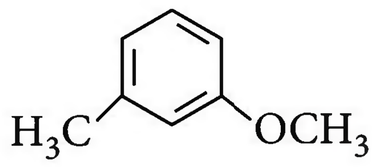
(d) $Al_2O_3 + HCl$

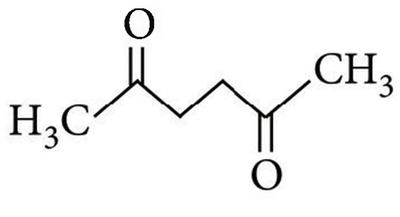
7. The major product of the following reaction is



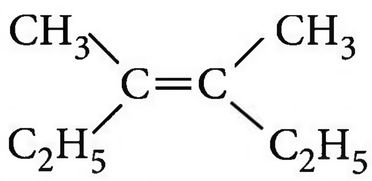
(a) 

(b) 

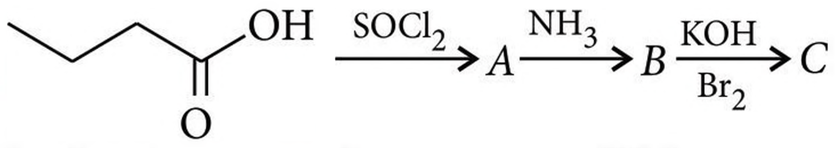
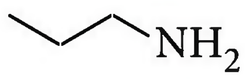
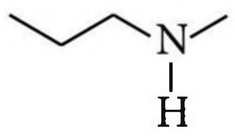
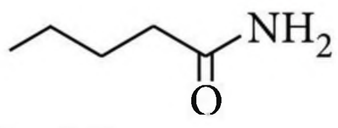
(c) 

(d) 

8. If a complex formed by one Ni^{2+} ion and some Cl^- ions and some PPh_3 molecules does not show geometrical isomerism and its solution does not show electrical conductance then, which is correct about the complex?
(a) It is square planar.
(b) It is tetrahedral.
(c) It is diamagnetic.
(d) None of the above is correct.

9. An alkene with molecular formula C_8H_{16} on oxidation with hot $KMnO_4$ gives acetone and 3-pentanone. The structure of the alkene is
(a) $(CH_3)_2C = C(C_2H_5)_2$
(b) 
(c) $(C_2H_5)_2C = CHCH_2CH_3$
(d) $(CH_3)_2C = CH(CH_2)_3CH_3$

10. The gas x at 1 atm is bubbled through a solution containing a mixture of 1M y - and 1M z - at 25°C. If the order of reduction potential is $z > y > x$, then
(a) y will oxidise x and not z
(b) y will oxidise z and not x
(c) y will oxidise both x and z
(d) y will reduce both x and z

11. 
In the above reaction sequence 'C' is
(a)  (b) 
(c)  (d) none of these.

12. In the following reactions,
$Mg \xrightarrow[Heat]{Air} X + Y \xrightarrow[Colourless\ gas]{H_2O} Z$
$Z \xrightarrow{H_2O} Solution \xrightarrow[(Blue\ coloured\ solution)]{CuSO_4} A$
substances X, Y, Z and A are respectively
(a) Mg_3N_2, MgO, NH_3, $CuSO_4 \cdot 5H_2O$
(b) $Mg(NO_3)_2$, MgO, H_2, $CuSO_4 \cdot 5H_2O$
(c) MgO, Mg_3N_2, NH_3, $[Cu(NH_3)_4]SO_4$
(d) $Mg(NO_3)_2$, MgO, H_2O_2, $CuSO_4 \cdot 5H_2O$

13. Which of the following is a mixed anhydride?
(a) Cl_2O_7 (b) Cl_2O_3
(c) ClO_2 (d) Cl_2O_5

14. 20 g of a sample of $Ba(OH)_2$ is dissolved in 10 mL of 0.5 N HCl solution. The excess of HCl was titrated with 0.2 N NaOH. The volume of NaOH used was 10 mL. The percentage of $Ba(OH)_2$ in the sample is
(a) 1.08 (b) 1.28 (c) 1.34 (d) 1.21

15. Decreasing order of reactivity in Williamson's ether synthesis of the following :
I. Me_3CCH_2Br II. $CH_3CH_2CH_2Br$
III. $CH_2{=}CHCH_2Cl$ IV. $CH_3CH_2CH_2Cl$
(a) III > II > IV > I (b) I > II > IV > III
(c) II > III > IV > I (d) I > III > II > IV

16. If 15/16 quantity of a radioactive element disintegrates in two hours, its half life would be
(a) 1 hour (b) 45 min
(c) 30 min (d) 15 min.

17. Which among the following is a hydride?
(a) Rogalite (b) Nitrolim
(c) Hydrolith (d) Minium

18. Inorganic graphite is
(a) $B_3N_3H_6$ (b) B_2H_6
(c) BN (d) BF_3

19. The standard molar enthalpies of formation of cyclohexane$_{(l)}$ and benzene$_{(l)}$ at 25°C are –156 and 49 kJ mol^{-1} respectively. The standard enthalpy of hydrogenation of cyclohexene$_{(l)}$ at 25°C is –119 kJ mol^{-1}. The magnitude of resonance energy of benzene is
(a) –152 kJ (b) 152 kJ
(c) 201 kJ (d) –201 kJ

20. Hyperconjugation is most useful for stabilizing which of the following carbocations?
(a) Neopentyl (b) *tert*-Butyl
(c) Isopropyl (d) Ethyl

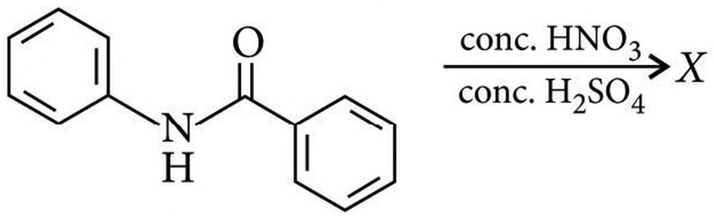
21. When the following five anions are arranged in order of decreasing ionic radius, the correct sequence is
(a) Se^{2-}, I^-, Br^-, O^{2-}, F^-
(b) I^-, Se^{2-}, O^{2-}, Br^-, F^-
(c) Se^{2-}, I^-, Br^-, F^-, O^{2-}
(d) I^-, Se^{2-}, Br^-, O^{2-}, F^-

22. The distance between an octahedral and tetrahedral voids in *fcc* lattice would be

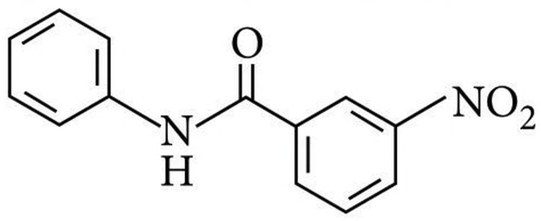
(a) $\sqrt{3}\,a$ (b) $\frac{\sqrt{3}a}{2}$

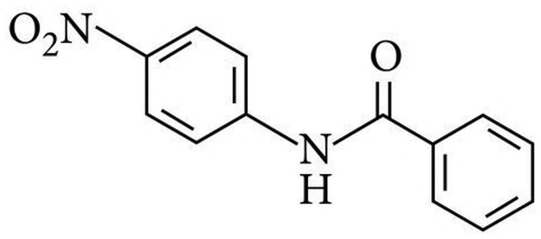
(c) $\frac{\sqrt{3}a}{3}$ (d) $\frac{\sqrt{3}a}{4}$

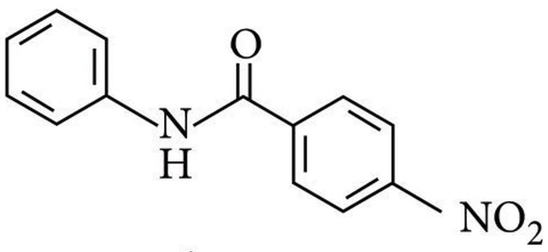
23. In the following reaction,

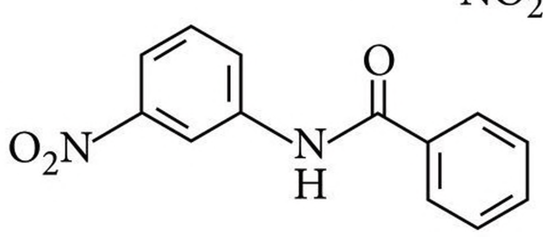


the structure of the major product *X* is

(a)


(b)


(c)


(d)


24. There is loss in weight when mixture of Li_2CO_3 and $Na_2CO_3.10H_2O$ is heated strongly. This loss is due to

(a) Li_2CO_3 (b) $Na_2CO_3.10H_2O$

(c) both (a) and (b) (d) none of these.

25. While testing BO_3^{3-}, there is green-edged flame on heating the salt with conc. H_2SO_4 and C_2H_5OH. Green colour is of

(a) $(CH_3)_3B$ (b) $(C_2H_5O)_3B$

(c) B_2O_3 (d) H_3BO_3

26. Of the following reduction processes,

(I) $Fe_2O_3 + C \rightarrow Fe$ (II) $ZnO + C \rightarrow Zn$

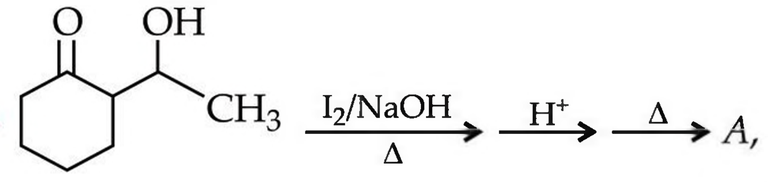
(III) $Ca_3(PO_4)_2 + C \rightarrow P$

(IV) $PbO + C \rightarrow Pb$

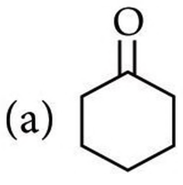
Correct processes are

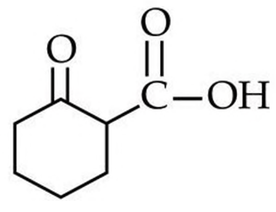
(a) (I), (II), (IV) (b) (I), (II), (III)

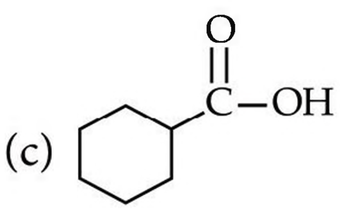
(c) (II), (IV) (d) all of these.

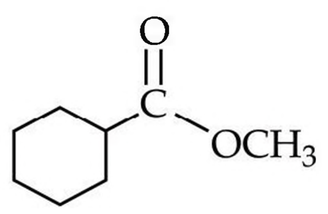
27.


A is

(a)


(b)


(c)


(d)


28. A 300 mL solution of NaCl was electrolysed for 6 minutes. If the pH of the final solution was 12.24, the average current used is

(a) 5 A (b) 1.32 A

(c) 1.4 A (d) 1.29 A

29. Chlorination of propane is carried out in the presence of sunlight. The % yield of major and minor alkyl halides will be

(a) 92 %, 8 %

(b) 70 %, 30 %

(c) 80 %, 20 %

(d) 86 %, 14 %

30. pK_a values of CH_3COOH, CCl_3COOH, C_6H_5OH and $C_6H_5SO_3H$ are 4.79, 0.9, 10.0 and –2.6. The leaving tendency of their conjugate bases increases in the order

(a) $C_6H_5O^- < CH_3COO^- < CCl_3COO^- < C_6H_5SO_3^-$

(b) $C_6H_5O^- < C_6H_5SO_3^- < CH_3COO^- < CCl_3COO^-$

(c) $CCl_3COO^- < C_6H_5O^- < C_6H_5SO_3^- < CH_3COO^-$

(d) $CCl_3COO^- < CH_3COO^- < C_6H_5SO_3^- < C_6H_5O^-$

ANSWER KEY

1. (b)	**2.** (a)	**3.** (a)	**4.** (d)	**5.** (b)
6. (b)	**7.** (d)	**8.** (b)	**9.** (a)	**10.** (a)
11. (a)	**12.** (c)	**13.** (c)	**14.** (b)	**15.** (c)
16. (c)	**17.** (c)	**18.** (a)	**19.** (a)	**20.** (b)
21. (d)	**22.** (d)	**23.** (b)	**24.** (c)	**25.** (b)
26. (d)	**27.** (a)	**28.** (c)	**29.** (a)	**30.** (a)

BRUSH UP

for

NEET/JEE

CLASS-XI

Brush up your concepts to get high rank in NEET/JEE (Main and Advanced) by reading this column. This specially designed column is updated year after year by a panel of highly qualified teaching experts well-tuned to the requirements of these Entrance Tests.

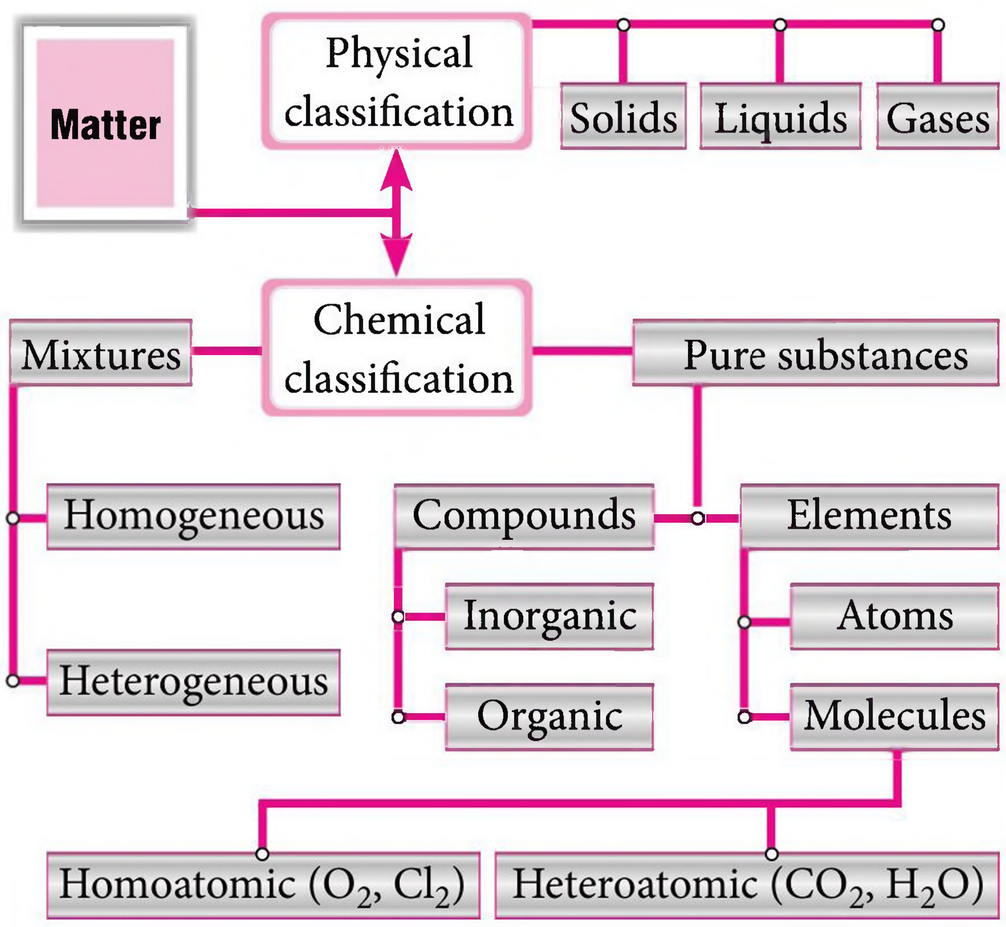
Unit 1

Some Basic Concepts of Chemistry | Structure of Atom

Some Basic Concepts of Chemistry

Matter

Matter is anything that occupies space and has mass.



Laws of Chemical Combinations

Law of Conservation of Mass (*Lavoisier*)
Matter can neither be created nor destroyed.

Law of Constant Composition or Definite Proportions (*Proust*)
A given compound always contains exactly the same proportion of elements by weight.

Law of Multiple Proportions (*Dalton*)
If two elements can combine to form more than one compound, the masses of one element that combine with a fixed mass of the other element, are in the ratio of small whole numbers.

Law of Reciprocal Proportions (*Richter*)
The ratio of the masses of two elements *A* and *B* which combine separately with a fixed mass of the third element *C* is either the same or some simple multiple of the ratio of the masses in which *A* and *B* combine directly with each other.

Avogadro's Law
Equal volumes of gases at the same temperature and pressure should contain equal number of molecules.

Gay Lussac's Law of Gaseous Volumes
When gases combine or are produced in a chemical reaction they do so in a simple ratio by volume provided all gases are at same temperature and pressure.

Dalton's Atomic Theory

Postulates of Dalton's Atomic Theory

- Matter consists of indivisible atoms.
- All the atoms of a given element have identical properties including identical mass. Atoms of different elements differ in mass.
- Compounds are formed when atoms of different elements combine in a fixed ratio.
- Chemical reactions involve reorganisation of atoms. These are neither created nor destroyed in a chemical reaction.

Masses and Their Methods of Evaluation

- *Atomic mass* is defined as the average relative mass of the atoms of the element as compared to the mass of C-12 isotope taken as 12 u.
  According to Dulong and Petit's method,

$$\text{Approx. atomic mass} = \frac{6.4}{\text{Specific heat}}$$

- *Molecular mass* is defined as the average relative mass of the molecules of a substance as compared to the mass of C-12 isotope taken as 12 u.
  From vapour density method,
  Molecular mass = 2 × Vapour density

Mole Concept

Moles

- No. of particles ÷ 6.023×10^{23}
- Mass in g ÷ Atomic mass / Mol. mass
- Volume in mL or L ÷ 22,400 mL or 22.4 L

Determination of Empirical and Molecular Formulae

$$\text{Molar ratio} = \frac{\text{Percentage of element}}{\text{Atomic mass}}$$

$$\text{Simplest molar ratio} = \frac{\text{Molar ratio}}{\text{Minimum molar ratio}}$$

Change to

Simplest whole number molar ratio = Simplest ratio × Integer

Write the numbers below the symbols of elements

Empirical formula → Molecular formula = n × Empirical formula

Structure of Atom

Sub-Atomic Particles

- *Atom* is not the smallest indivisible particle but have a complex structure of its own.

	Electron	Proton	Neutron
Discoverer	J.J. Thomson (1897)	E. Goldstein (1911)	James Chadwick (1932)
Position	Moves around the nucleus	Constituent of nucleus	Constituent of nucleus
Symbol	e or e^-	p	n
Approximate relative mass	1/1836	1	1
Approximate relative charge	–1	+1	No charge
Mass in kg	9.109×10^{-31}	1.673×10^{-27}	1.675×10^{-27}
Mass in amu	5.485×10^{-4}	1.007	1.008
Actual charge	1.602×10^{-19}	1.602×10^{-19}	0

Thomson Model of Atom

- J.J. Thomson proposed that, positive charge is spread over a sphere of radius ≈ 10^{-8} cm and electrons are embedded in it. This model explains the electrical neutrality of atom but not the other observations like spectra and α-scattering experiment.

Rutherford's Model of Atom

- Rutherford proposed that, the nucleus of an atom is hard dense core and consists of protons while electrons revolve around the nucleus. It could not explain the line spectra of elements.

Isotopes, Isobars, Isotones, Isodiaphers, Isosters

- *Isotopes* are different atoms of same element having same atomic number but different mass numbers. *e.g.*, $^{1}_{1}H$, $^{2}_{1}H$, $^{3}_{1}H$; $^{35}_{17}Cl$, $^{37}_{17}Cl$
- *Isobars* are atoms of different elements having same mass number but different atomic numbers. *e.g.*, $^{40}_{18}Ar$, $^{40}_{19}K$, $^{40}_{20}Ca$
- *Isotones* are atoms of different elements containing same number of neutrons. *e.g.*, $^{14}_{6}C$, $^{15}_{7}N$, $^{16}_{8}O$
- *Isodiaphers* are atoms having same isotopic number (*i.e.*, no. of neutrons – no. of protons = same) *e.g.*, $^{235}_{92}U$, $^{231}_{90}Th$
- *Isosters* are molecules having same number of atoms and electrons. *e.g.*, CO_2, N_2O

Electromagnetic Radiations

- These radiations consist of electric and magnetic fields that oscillate in directions perpendicular to each other and to the direction in which the wave is travelling. These radiations do not require any medium for transmission.

Scientist of the Month

Homi Nusserwanji Sethna

Homi Nusserwanji Sethna
(24 Aug. 1923 - 5 Sep. 2010)

Homi Nusserwanji Sethna was an Indian nuclear scientist and a chemical engineer, gaining international fame as the Chairman of the Atomic Energy Commission (India) during the time when the first nuclear test, code name Smiling Buddha in Pokhran Test Range in 1974 was conducted. He was the primary and central figure in India's civilian nuclear program as well as the construction of nuclear power plants.

Biography

Sethna was born to a Parsi family on 24 August 1923 in Mumbai. He did his schooling from St. Xavier's High School, Fort, Mumbai and higher studies from the University of Michigan Ann Arbor. Earlier in his career, he had full technical responsibility for setting up of the Thorium extraction plant at Alwaye, Kerala India, for separation of rare earth from monazite sands.

He completed the construction of the Thorium plant and the plant for the production of nuclear grade uranium metal at Trombay, India. His first major challenging assignment was the setting up of the Plutonium Plant at Trombay in 1959. This was designed and constructed entirely by Indian scientists and engineers under H. N. Sethna as the Project Engineer. The Uranium Mill at Jaduguda, Jharkhand was also constructed under his guidance in 1967. He was also the Project Manager of a 40 MW reactor called Canada-India Reactor in 1956-58.

Honors

- He was the guiding force behind the first peaceful nuclear explosion, Project Smiling Buddha in India on 18 May 1974, and in 1975, Homi Sethna, then chairman of the Atomic Energy Commission, Raja Ramanna and Basanti Dulal Nagchaudhuri (head of the DRDO) received the Padma Vibhushan.
- He was formerly Chairman of Atomic Energy Commission, in 1976 he became the first chairman of Maharashtra Academy of Sciences, located in Pune, Maharashtra.

Awards

- 1959: Padma Shri
- 1960: SS Bhatnagar Prize
- 1966: Padma Bhushan
- 1967: University of Michigan Sesquicentennial Award
- 1975: Padma Vibhushan

Electromagnetic Spectrum

It is the arrangement of various types of electromagnetic radiations in the order of their increasing (or decreasing) wavelength (or frequencies).

Cosmic rays	γ-rays	X-rays	UV	Visible	IR	Micro-waves	Radio-waves

Increasing wavelength or decreasing frequency

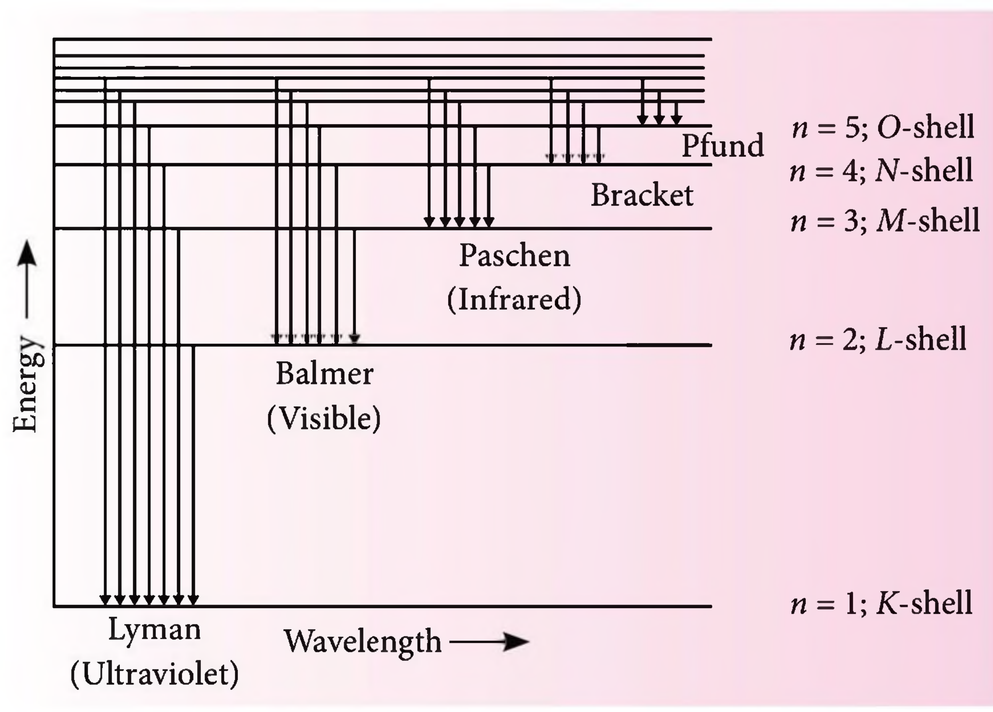
Atomic Spectra of Hydrogen

In discharge tube experiments, light spectrum emitted by hydrogen consists of a large number of lines of different wavelengths.

Rydberg formula : $\bar{\nu} = \frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)Z^2$

where, $n_2 > n_1$; R_H is Rydberg constant and has a value equal to 109,677 cm^{-1}.

The number of spectral lines possible for hydrogen or hydrogen like species when the electrons from n^{th} energy level return to ground state in different atoms $= \frac{1}{2}n(n-1)$



Bohr's Atomic Model

Postulates of Bohr's Atomic Model

- Atom consists of a small, heavy and positively charged nucleus in centre, and electrons revolve around the nucleus in fixed paths called *orbits*.
- Energy of an electron in the orbit does not change with time.
- The electron can revolve only in those orbits whose angular momentum is an integral multiple of $h/2\pi$ *i.e.*, $mvr = \frac{nh}{2\pi}$, $n = 1, 2, 3, ...$
- When electron jumps from one level to another, energy is either emitted or absorbed.
  - The energy difference between two states is given by $\Delta E = E_2 - E_1$
  - As the distance of the orbits increases from the nucleus, the energy gap goes on decreasing, *i.e.*, $E_2 - E_1 > E_3 - E_2 > E_4 - E_3 > .....$

Derivations from Bohr's Theory

For Hydrogen and Hydrogen like Particles

- Energy (E_n): $\frac{-1312\ Z^2}{n^2}$ kJ/mol
- Radius (r_n): $\frac{0.529\ n^2}{Z}$ Å
- Speed (v_n): $\frac{2.18\times10^8}{n}\times Z$ $cm\ sec^{-1}$

Limitations of Bohr's Model

Limitations of Bohr's Theory

- Fails to explain electronic repulsions in multielectronic atoms.
- Does not support to the assumption, $mvr = \frac{nh}{2\pi}$.
- Does not explain Stark effect and Zeeman effect.
- Does not explain the distribution of electrons in orbits.
- Against de-Broglie and Heisenberg's uncertainty principles.

Planck's Quantum Theory

A body can emit or absorb energy not continuously but discontinuously in the form of small packets of energy called *quanta*. A quantum of light is called a *photon*. It explains photoelectric effect and black body radiations.

Photoelectric Effect

- $K.E. = h(\nu - \nu_0) = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)$
- *K.E.* of electrons ∝ Frequency of incident radiations
- No. of electrons ejected ∝ Intensity of incident radiations
- Each photon having energy equal to or greater than threshold energy can eject only one electron.

Dual Nature of Matter

Every material particle in motion has dual nature *i.e.*, particle nature and wave nature and the relation between them is called *de Broglie relation*.

$$\text{Wavelength of wave } (\lambda) = \frac{h}{mv}$$

According to Heisenberg's uncertainty principle, the product of uncertainty in the position (Δx) and uncertainty in the momentum (Δp) is always constant.

$$\Delta x \times \Delta p \geq \frac{h}{4\pi}$$

Quantum or Wave Mechanical Model of Atom

Schrodinger wave equation, based on the wave motion associated with the particles is

$$\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} + \frac{8\pi^2 m}{h^2}(E - V)\psi = 0$$

ψ has no physical significance but ψ^2 gives the intensity of the electron wave at that point.

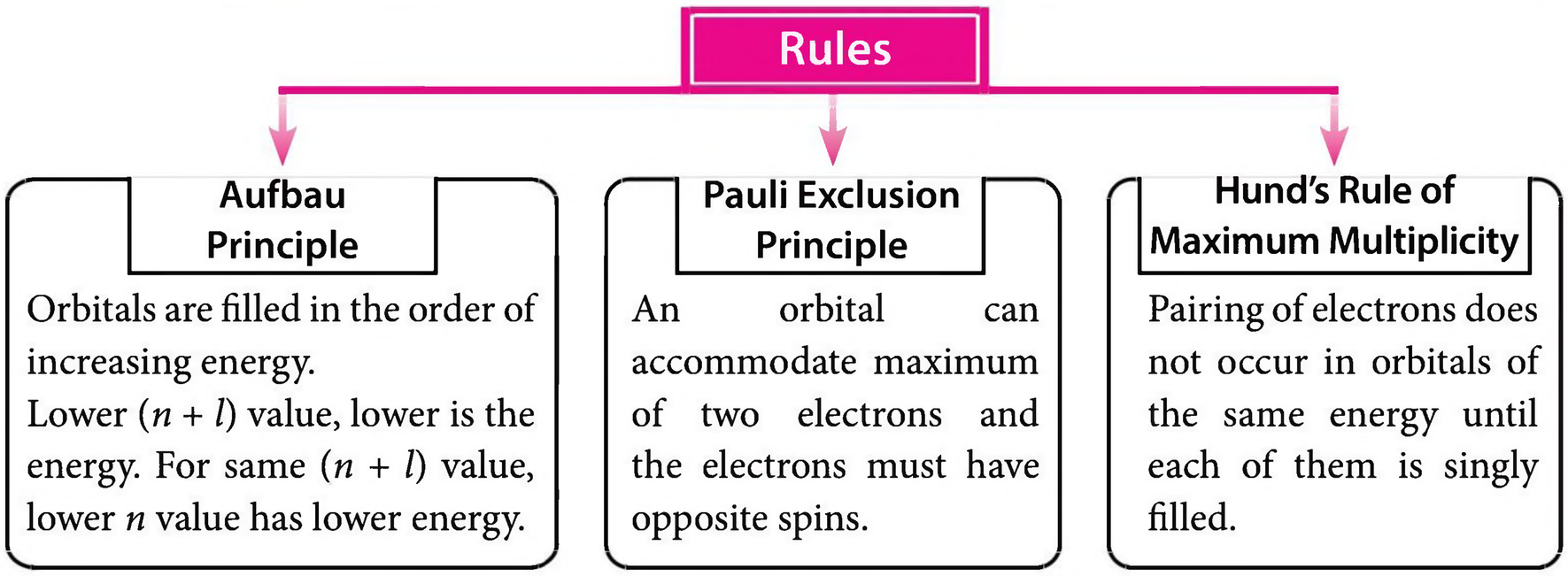
An atomic orbital may be defined as three dimensional space around the nucleus where the probability of finding an electron is maximum (upto 90-95%).

Quantum Numbers

Quantum Numbers

- Principal quantum number (n) can have integer values. It represents main shell of the electron and the maximum no. of electrons present in the shell is $2n^2$.
- Azimuthal quantum number (l) can have values from 0 to $n - 1$. It represents no. of subshells in the main shell.
- Magnetic quantum number (m_l) can have values from $-l$ to $+l$ including zero. It represents no. of orbitals present in any subshell.
- Spin quantum number (m_s) can have values of $+\frac{1}{2}$ and $-\frac{1}{2}$ which represents clockwise and anti-clockwise direction of an electron spin.

Rules for Distribution of Electrons



WRAP it up!

1. Photoelectric emission is observed from a surface for frequencies ν_1 and ν_2 of incident radiations ($\nu_1 > \nu_2$). If the maximum kinetic energy of photoelectrons in the two cases are in the ratio of 1 : 2, then threshold frequency ν_0 is given by
   (a) $\nu_2 - \nu_1$ (b) $2\nu_1 - \nu_2$
   (c) $2\nu_2 - \nu_1$ (d) $\frac{\nu_2 - \nu_1}{2}$

2. If the fertilizers listed below are priced according to their nitrogen content, which will be the least expensive per 50 kg bag?
   (a) Urea, $(NH_2)_2CO$ (b) Ammonia, NH_3
   (c) Ammonium nitrate, NH_4NO_3
   (d) Guanidine, $HNC(NH_2)_2$

3. In which case is number of molecules of water maximum?
   (a) 18 mL of water (b) 0.18 g of water
   (c) 0.00224 L of water vapours at 1 atm and 273 K
   (d) 10^{-3} mol of water **(NEET 2018)**

4. Which of the following is the energy of a possible excited state of hydrogen?
   (a) –3.4 eV (b) +6.8 eV
   (c) +13.6 eV (d) –6.8 eV

5. Energy for 7.25×10^{15} photons of 5.37×10^{14} s^{-1} frequency in Einstein unit is
   (a) 1.20×10^{-8} (b) 2.58×10^{-3}
   (c) 3.56×10^{-19} (d) 8.33×10^{2}

6. Uncertainty in position of an electron (mass = 9.1×10^{-28} g) moving with a velocity of 3×10^4 cm/s accurate up to 0.001% will be
   (a) 1.93 cm (b) 3.84 cm
   (c) 5.76 cm (d) 7.68 cm

7. If the radius of 2nd Bohr orbit of hydrogen atom is r_2. The radius of 3rd Bohr orbit will be
   (a) $\frac{4}{9}r_2$ (b) $4r_2$ (c) $\frac{9}{4}r_2$ (d) $9r_2$

8. 5 moles of AB_2 weigh 125×10^{-3} kg and 10 moles of A_2B_2 weigh 300×10^{-3} kg. The molar mass of A (M_A) and molar mass of B (M_B) in kg mol^{-1} are
   (a) $M_A = 25 \times 10^{-3}$ and $M_B = 50 \times 10^{-3}$
   (b) $M_A = 5 \times 10^{-3}$ and $M_B = 10 \times 10^{-3}$
   (c) $M_A = 10 \times 10^{-3}$ and $M_B = 5 \times 10^{-3}$
   (d) $M_A = 50 \times 10^{-3}$ and $M_B = 25 \times 10^{-3}$
   (JEE Main 2019)

9. A particular electromagnetic radiation with wavelength 200 nm
   (a) has a higher frequency than radiation with wavelength 400 nm
   (b) is in the visible region of the electromagnetic spectrum
   (c) has a greater speed in vacuum than does radiation of wavelength 400 nm
   (d) has a greater energy content per photon than does radiation with wavelength 100 nm.

10. If n and l are the principal and azimuthal quantum numbers, then the expression for calculating the total number of electrons in any energy level is

(a) $\sum_{l=1}^{l=n} 2(2l+1)$ (b) $\sum_{l=1}^{l=n-1} 2(2l+1)$

(c) $\sum_{l=0}^{l=n+1} 2(2l+1)$ (d) $\sum_{l=0}^{l=n-1} 2(2l+1)$

11. The number of moles of hydrogen molecules required to produce 20 moles of ammonia through Haber's process is

(a) 40 (b) 10

(c) 20 (d) 30 **(NEET 2019)**

12. Energy required to stop the ejection of electrons from Cu plate is 0.24 eV. Calculate the work function when radiations of λ = 253.7 nm strikes the plate.

(a) 4.65 eV (b) 2.42 eV

(c) 4.89 eV (d) 7.82 eV

13. Which is the correct order of increasing energy of the listed orbitals in an atom of titanium?
(At. no. $Z = 22$)

(a) 4*s* 3*s* 3*p* 3*d* (b) 3*s* 3*p* 3*d* 4*s*

(c) 3*s* 3*p* 4*s* 3*d* (d) 3*s* 4*s* 3*p* 3*d*

14. Which are in the ascending order of wavelength?

(a) $H_{(3\rightarrow 2)}$, $H_{(4\rightarrow 2)}$, $H_{(5\rightarrow 2)}$ ..... lines in Balmer series of hydrogen atom

(b) Lyman limit, Balmer limit, Paschen limit in the hydrogen spectrum

(c) Blue, violet, yellow, red colours in solar spectrum

(d) X-rays, Cosmic rays, γ-rays

15. The number of water molecules is maximum in

(a) 1.8 gram of water (b) 18 gram of water

(c) 18 moles of water (d) 18 molecules of water.

16. Amongst the following statements that which was not proposed by Dalton, was

(a) all the atoms of a given element have identical properties including identical mass. Atoms of different elements differ in mass

(b) matter consists of indivisible atoms

(c) when gases combine or reproduced in a chemical reaction they do so in a simple ratio by volume provided all gases are at the same T and P

(d) chemical reactions involve reorganization of atoms. These are neither created nor destroyed in a chemical reaction. **(JEE Main 2020)**

17. One mole of P_4 molecules contains

(a) 1 molecule (b) 4 molecules

(c) $\frac{1}{4} \times 6.022 \times 10^{23}$ atoms

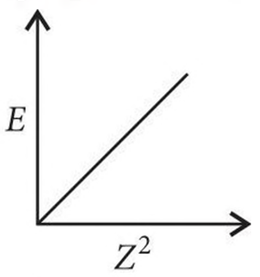
(d) 24.092×10^{23} atoms.

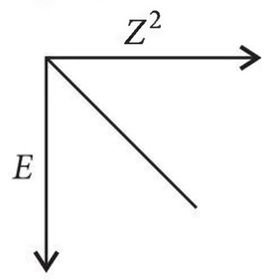
18. Cortisone is a molecular substance containing 21 atoms of carbon per molecule. The mass percentage of carbon in cortisone is 69.98%. Its molar mass is

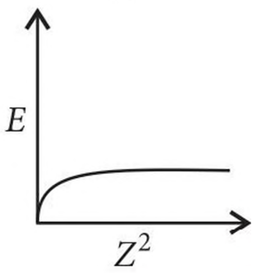
(a) 176.5 (b) 252.2 (c) 287.6 (d) 360.1

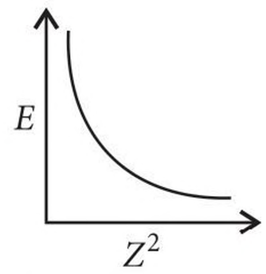
19. The energy of an electron moving in n^{th} Bohr's orbit of an element is given by $E_n = \frac{-13.6}{n^2} Z^2$ eV/atom.

The graph of E *vs* Z^2 (keeping 'n' constant) will be

(a) 

(b) 

(c) 

(d) 

20. The two electrons X and Y have following sets of quantum numbers:

	n	l	m_l	m_s
X =	3	2	−2	$+\frac{1}{2}$
Y =	3	0	0	$+\frac{1}{2}$

Which of the following is the correct statement?

(a) X and Y have same energy.

(b) X has greater energy than Y.

(c) X has less energy than Y.

(d) X and Y represent same electron.

21. Number of waves made by a Bohr electron in one complete revolution in 3rd orbit is

(a) 2 (b) 3 (c) 4 (d) 1

22. Two electrons occupying the same orbital are distinguished by

(a) azimuthal quantum number

(b) spin quantum number

(c) principal quantum number

(d) magnetic quantum number.

23. What is the ratio of the masses of oxygen that are combined with 1.08 g of nitrogen in the compounds N_2O_3 and NO?

(a) 2 : 3 (b) 1 : 3 (c) 3 : 2 (d) 1 : 2

CONCEPT MAP

CLASS XI

Trends and Anomalies in *s*- and *p*-Block Elements

Generally in a group, elements show a regular trend in their physical and chemical properties with increase in their atomic numbers. But some of the elements show exceptional behaviour and anomalies.

General Trends in Properties of *s*- and *p*-Block Compounds

Carbonates and Bicarbonates Stability

- $Li_2CO_3 < Na_2CO_3 < K_2CO_3 < Rb_2CO_3 < Cs_2CO_3$
- $LiHCO_3 < NaHCO_3 < KHCO_3 < RbHCO_3 < CsHCO_3$
- $BeCO_3 < MgCO_3 < CaCO_3 < SrCO_3 < BaCO_3$

Basic Strength, Solubility and Stability of Hydroxides

- $LiOH < NaOH < KOH < RbOH < CsOH$
- $Be(OH)_2 < Mg(OH)_2 < Ca(OH)_2 < Sr(OH)_2 < Ba(OH)_2$
- $\underbrace{B(OH)_3}_{\text{Acidic}} < \underbrace{Al(OH)_3 < Ga(OH)_3}_{\text{Amphoteric}} < \underbrace{In(OH)_3 < Tl(OH)_3}_{\text{Basic}}$

Solubility and Basic Strength of Oxides

- $Li_2O < Na_2O < K_2O < Rb_2O < Cs_2O$
- $\underbrace{BeO}_{\text{Amphoteric}} < \underbrace{MgO}_{\text{Weakly basic}} < \underbrace{CaO < SrO < BaO}_{\text{Strongly basic}}$
- $\underbrace{B_2O_3}_{\text{Weakly acidic}} < \underbrace{Al_2O_3 < Ga_2O_3}_{\text{Amphoteric}} < \underbrace{In_2O_3 < Tl_2O_3}_{\text{Basic}}$

Stability of Peroxides and Superoxides

- $Na_2O_2 < K_2O_2 < Rb_2O_2 < Cs_2O_2$
- $NaO_2 < KO_2 < RbO_2 < CsO_2$
- $MgO_2 < CaO_2 < SrO_2 < BaO_2$

Solubility in Water

- $LiF < NaF < KF < RbF < CsF$
- $LiCl < NaCl < KCl < RbCl < CsCl$
- $NaF < NaCl < NaBr < NaI$
- $BeCl_2 > MgCl_2 > CaCl_2 > SrCl_2 > BaCl_2$
- $BF_3 < BCl_3 < BBr_3$

Stability of Halides

- $CX_4 > SiX_4 > GeX_4 > SnX_4 > PbX_4$
- $CF_4 > CCl_4 > CBr_4 > CI_4$
- $PbX_2 > SnX_2 > GeX_2 > SiX_2$

Solubility of Sulphates

- $BeSO_4 > MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$

Stability of Sulphate

- $BeSO_4 < MgSO_4 < CaSO_4 < SrSO_4$

Anomalous Behaviour of First Element of Group

Due to

- Small size
- High electronegativity
- High ionization enthalpy
- Absence of *d*-orbitals in valence shell

Anomalous Behaviour of Lithium

- Melting and boiling points are comparatively high.
- Lithium forms nitride while other alkali metals do not.
  $6Li + N_2 \rightarrow 2Li_3N$
- Lithium hydroxide and carbonate decompose on heating, while other alkali metal hydroxides and carbonates do not.
  $2LiOH \xrightarrow{\Delta} Li_2O + H_2O$ $\quad Li_2CO_3 \xrightarrow{\Delta} Li_2O + CO_2\uparrow$

Anomalous Behaviour of Beryllium

- Beryllium is harder than other group members.
- Beryllium does not react with water even at high temperature.
- Beryllium forms covalent compounds. Because of covalent character salts of beryllium are easily hydrolysed.
  $BeCO_3 + 4H_2O \rightarrow [Be(H_2O)_4]^{2+} + CO_3^{2-}$

Anomalous Behaviour of Boron

- Boron is hard and has high melting and boiling points.
- Boron forms only covalent compounds while others form both ionic and covalent compounds.
- The oxide and hydroxide of boron are weakly acidic.
  $B_2O_3 + 2NaOH \rightarrow 2NaBO_2 + H_2O$
  $B(OH)_3 + NaOH \rightarrow NaBO_2 + 2H_2O$

Anomalous Behaviour of Carbon

- Due to small size and high electronegativity, carbon has a strong tendency to form $p\pi$-$p\pi$ multiple bonds.
- Carbon has high tendency of catenation. Tendency for catenation : $C >> Si > Ge \approx Sn >> Pb$

Stability of Hydrides

- $LiH > NaH > KH > RbH > CsH$
- $CH_4 > SiH_4 > GeH_4 > SnH_4 > PbH_4$

Lewis Acid Character

- $BI_3 > BBr_3 > BCl_3 > BF_3$

Stability of Nitrates

- $Be(NO_3)_2 < Mg(NO_3)_2 < Ca(NO_3)_2 < Sr(NO_3)_2 < Ba(NO_3)_2$

Surface Chemistry

Surface chemistry is the study of chemical reactions at interfaces. It is closely related to surface engineering which aims at modifying the chemical composition of a surface for desired improvement. Surface science has importance in catalysis, electrochemistry and geochemistry.

CONCEPT MAP

CLASS XII

Applications of Colloids

Colloids have very vast applications from food products to industries like rubber etc.

In Nature and Everyday Life

Food Articles

Number of food articles that we eat, are colloidal in nature, *e.g.*,
- **Milk :** Fat dispersed in water.
- **Bread :** Air dispersed in baked dough.

Medicines

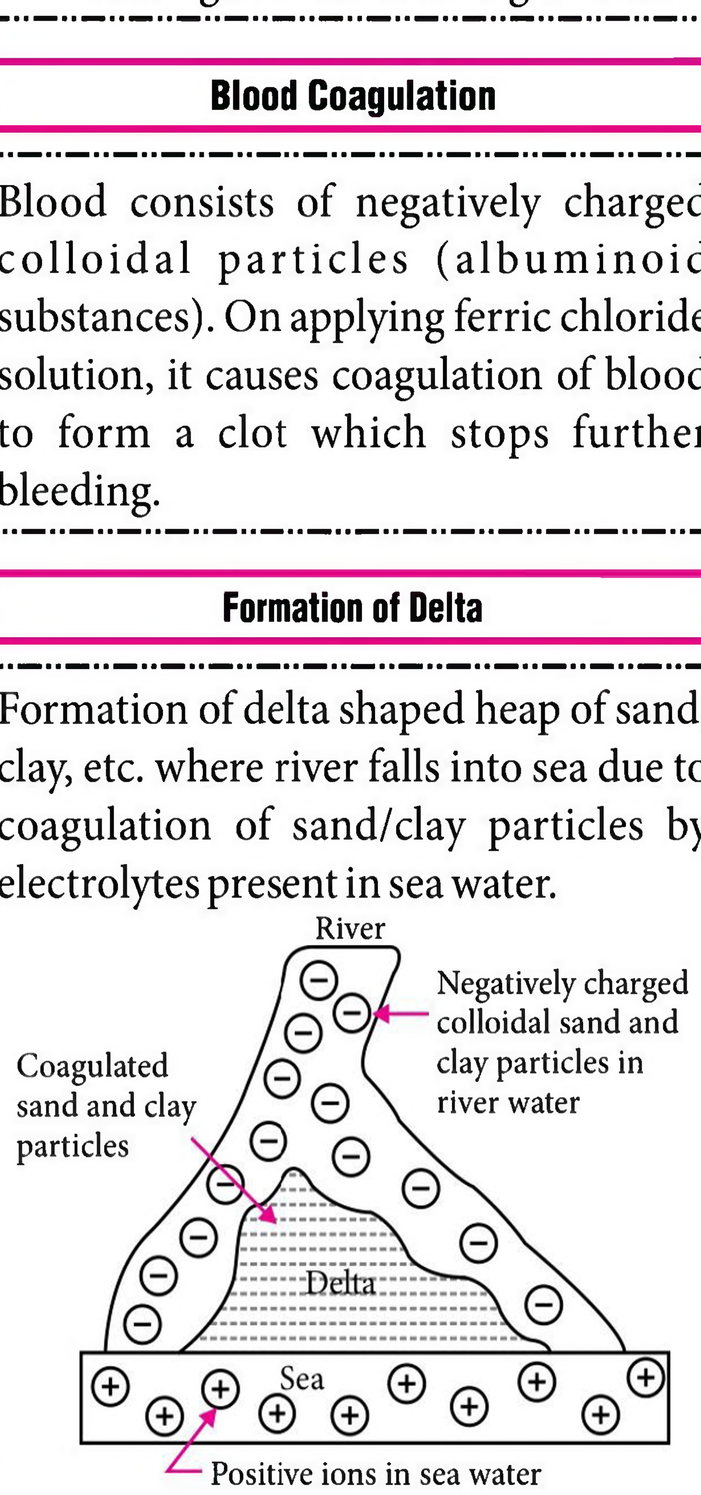
- Colloidal medicines are more effective as they are easily absorbed in the body, *e.g.*,
  - **Silver colloid :** Germicidal
  - **Copper colloid :** Anticancer
  - **Mercury colloid :** Antisyphilis
- Colloidal dispersion of gelatin is used in coating over tablets and granules.

Blood Coagulation

Blood consists of negatively charged colloidal particles (albuminoid substances). On applying ferric chloride solution, it causes coagulation of blood to form a clot which stops further bleeding.

Formation of Delta

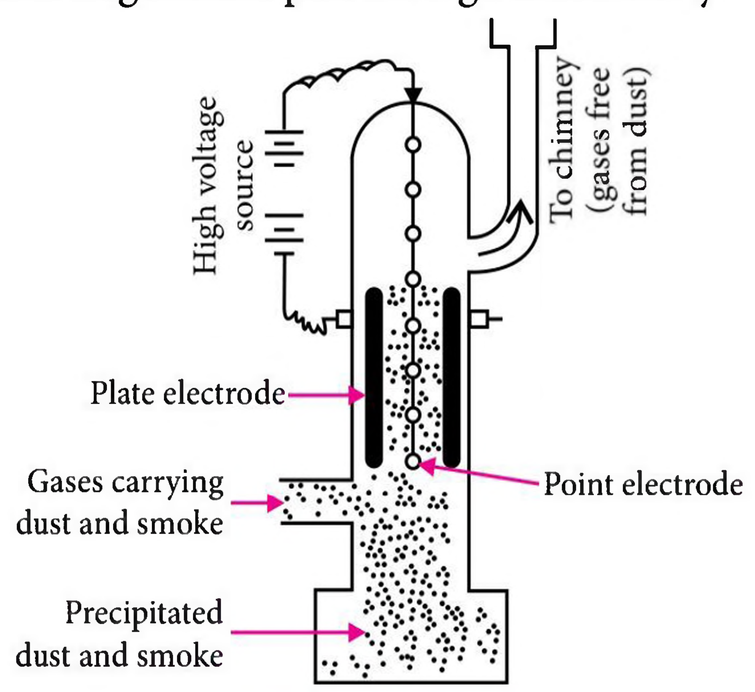
Formation of delta shaped heap of sand, clay, etc. where river falls into sea due to coagulation of sand/clay particles by electrolytes present in sea water.



In Industries

Smoke Precipitation

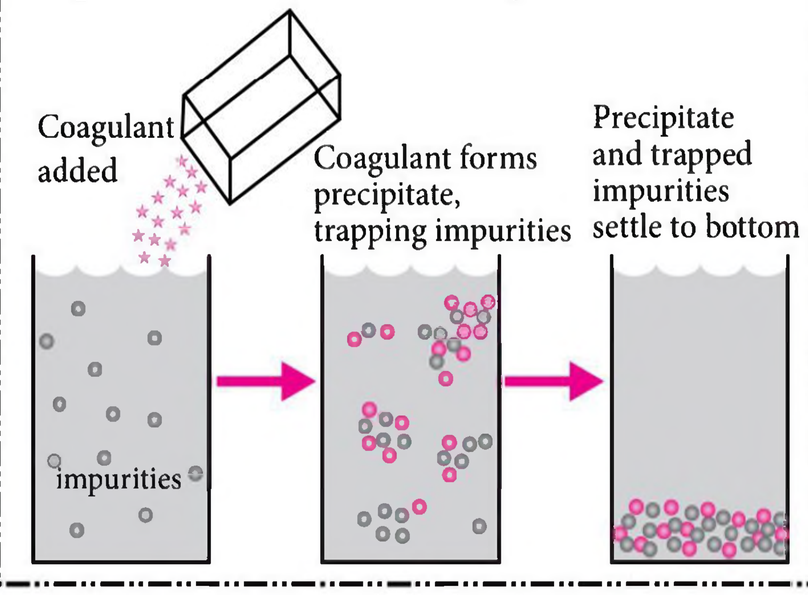
Smoke is a big problem for environment as it is the major cause of air pollution. Coagulation of the dispersed colloidal particles (smoke) occurs on metal plates before allowing them to pass through the chimney.



Cottrell Precipitator

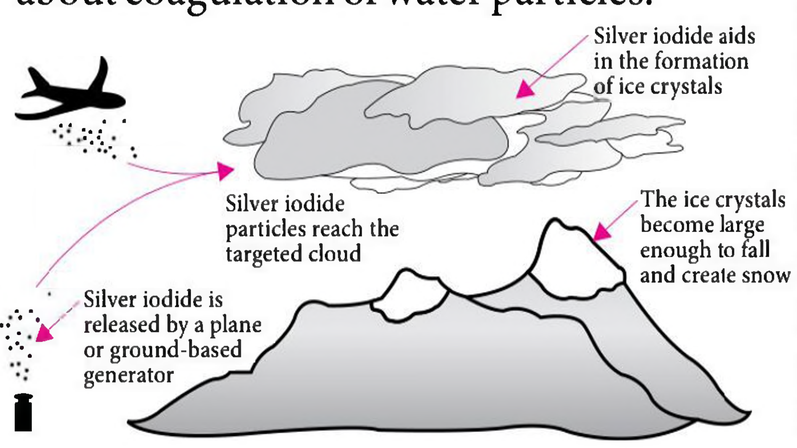
Purification of Drinking Water

Addition of the electrolyte (like alum) for water purification is based on the fact that impure water is a colloidal system.



Artificial Rain

Due to mixing of oppositely charged sand or common salt with the clouds to bring about coagulation of water particles.



Applications of Adsorption

Adsorption finds extensive applications in research laboratories and in industries. It can be used to remove certain classes of pollutants from air and industrial waste water.

In Gas Masks

Gas masks are used to adsorb poisonous gases (*e.g.*, Cl_2, CO, oxides of sulphur etc.) and thus purify the air for breathing. Activated charcoal is used for this purpose.

Removal of Colouring Matter from Solution

Many substances such as sugar, juice and vegetable oils (having coloured impurities) can be decolourised by using adsorbents like activated charcoal or fuller's earth, *e.g.*, animal charcoal is used as a decolouriser in the manufacture of cane sugar.

Heterogeneous Catalysis

Mostly heterogeneous catalytic reactions proceed through the adsorption of gaseous reactants on solid catalyst, *e.g.*,
- Finely powdered nickel is used for the hydrogenation of oils.
- Finely divided vanadium pentaoxide (V_2O_5) is used in the Contact process for the manufacture of sulphuric acid.

In Curing Disease

Some drugs can adsorb the germs and kill them hence, save us from diseases.

Separation of Inert Gases

Due to the difference in degree of adsorption of gases by charcoal, a mixture of inert gases can be separated by adsorption on coconut charcoal at different temperatures.

24. If Avogadro number N_A, is changed from 6.022×10^{23} mol^{-1} to 6.022×10^{20} mol^{-1}, this would change
(a) the mass of one mole of carbon
(b) the ratio of chemical species to each other in a balanced equation
(c) the ratio of elements to each other in a compound
(d) the definition of mass in units of grams.

25. 4*d*, 5*p*, 5*f* and 6*p* orbitals are arranged in the order of decreasing energy. The correct option is
(a) $5f > 6p > 4d > 5p$ (b) $5f > 6p > 5p > 4d$
(c) $6p > 5f > 5p > 4d$ (d) $6p > 5f > 4d > 5p$
(NEET 2019)

Integer / Numerical Value Type

26. Dissolving 120 g of urea (mol. wt. 60) in 1000 g of water gave a solution of density 1.15 g/mL. The molarity of the solution is _____.

27. The amount of energy required to remove the electron from a Li^{2+} ion in its ground state is how many times greater than the amount of energy needed to remove the electron from an H atom in its ground state?

28. Calculate the accelerating potential that must be applied to a proton beam to give it an effective wavelength of 0.005 nm.

29. Find the quantum no. '*n*' corresponding to the excited state of He^+ ion if on transition to the ground state that ion emits two photons in succession with wavelengths 108.5 nm and 30.4 nm.

30. 3 g of activated charcoal was added to 50 mL of acetic acid solution (0.06 N) in a flask. After an hour it was filtered and the strength of the filtrate was found to be 0.042 N. The amount of acetic acid adsorbed (per gram of charcoal) is

SOLUTIONS

1. **(b):** $h\nu_1 = h\nu_0 + (K.E.)_1$
$h\nu_2 = h\nu_0 + (K.E.)_2$
$$\frac{h(\nu_1 - \nu_0)}{h(\nu_2 - \nu_0)} = \frac{(K.E.)_1}{(K.E.)_2} = \frac{1}{2}$$
$2(\nu_1 - \nu_0) = \nu_2 - \nu_0 \Rightarrow \nu_0 = 2\nu_1 - \nu_2$

2. **(c):** % of N in $(NH_2)_2CO = \frac{28}{60} \times 100 = 46.7\%$
% of N in $NH_3 = \frac{14}{17} \times 100 = 82.3\%$
% of N in $NH_4NO_3 = \frac{28}{80} \times 100 = 35\%$
% of N in $HNC(NH_2)_2 = \frac{42}{59} \times 100 = 71.1\%$
Lower the percentage of N in the fertilizer, lower is its price hence, 50 kg bag of NH_4NO_3 is least expensive.

3. **(a):** (a) Mass of water = $V \times d = 18 \times 1 = 18$ g
Molecules of water = mole $\times N_A = \frac{18}{18} N_A = N_A$
(b) Molecules of water = mole $\times N_A = \frac{0.18}{18} N_A$
$= 10^{-2} N_A$
(c) Moles of water = $\frac{0.00224}{22.4} = 10^{-4}$
Molecules of water = mole $\times N_A = 10^{-4} N_A$
(d) Molecules of water = mole $\times N_A = 10^{-3} N_A$

4. **(a)**

5. **(a):** Energy of 7.25×10^{15} photons with frequency 5.37×10^{14} s^{-1} is
$E = Nh\nu = 7.25 \times 10^{15} \times h \times 5.37 \times 10^{14}$
Energy of N_0 photons with same frequency
$E' = N_0 h\nu = 6.02 \times 10^{23} \times h \times 5.37 \times 10^{14}$
$$\text{Number of Einstein} = \frac{E}{E'} = \frac{7.25 \times 10^{15}}{6.02 \times 10^{23}}$$
$= 1.20 \times 10^{-8}$ Einstein

6. **(a):** $\Delta x \cdot \Delta v = \frac{h}{4\pi m}$
$$\Delta x = \frac{h}{4\pi m \Delta v}$$
$$= \frac{6.626 \times 10^{-27}}{4\pi \times 9.1 \times 10^{-28} \times 3 \times 10^4 \times \frac{0.001}{100}} = 1.93 \text{ cm}$$

7. **(c):** $r_n = \frac{n^2 h^2}{4\pi^2 k m Z e^2}$ $\therefore$ $\frac{r_2}{r_3} = \frac{2^2}{3^2}$ $\therefore$ $r_3 = \frac{9}{4} r_2$

8. **(b):** Weight of $AB_2 = 125 \times 10^{-3}$ kg
Moles of $AB_2 = 5$ moles
Weight of $A_2B_2 = 300 \times 10^{-3}$ kg
Moles of $A_2B_2 = 10$ moles

As we know, Moles $= \dfrac{\text{Given weight}}{\text{Molar mass}}$

$\therefore$ Molar mass $= \dfrac{\text{Given weight}}{\text{Moles}}$

Molar mass of $AB_2 = \dfrac{125\times10^{-3}\text{ kg}}{5\text{ moles}} = 25\times10^{-3}\text{ kg mol}^{-1}$

Molar mass of $A_2B_2 = \dfrac{300\times10^{-3}\text{ kg}}{10\text{ moles}}$

$= 30\times10^{-3}\text{ kg mol}^{-1}$

$A + 2B = 25\times10^{-3}$ ...(i)

$2A + 2B = 30\times10^{-3}$

$A + B = 15\times10^{-3}$ ...(ii)

From equation (i) and (ii), we get

$B = 10\times10^{-3}\text{ kg mol}^{-1}$; $A = 5\times10^{-3}\text{ kg mol}^{-1}$

Therefore, $M_A = 5\times10^{-3}\text{ kg mol}^{-1}$ and

$M_B = 10\times10^{-3}\text{ kg mol}^{-1}$

9. (a) : Frequency is inversely proportional to the wavelength of radiation.

10. (d)

11. (d): Haber's process, $N_2 + 3H_2 \rightarrow 2NH_3$

2 moles of NH_3 are formed by 3 moles of H_2.

$\therefore$ 20 moles of NH_3 will be formed by 30 moles of H_2.

12. (a) : Energy of photon = Work function + $\dfrac{1}{2}mv^2$

Energy of photon = Work function + eV_0 ...(i)

where, e is electronic charge and V_0 is stopping potential and eV_0 is equal to energy required to stop the ejection of electron.

$\because$ Energy of photon $= \dfrac{hc}{\lambda}$

$= \dfrac{6.626\times10^{-34}\times3.0\times10^{8}}{253.7\times10^{-9}} = 7.835\times10^{-19}\text{ J}$

$= \dfrac{7.835\times10^{-19}}{1.602\times10^{-19}}\text{ eV} = 4.89\text{ eV}$

From equation (i), 4.89 = Work function + 0.24

$\therefore$ Work function = 4.65 eV

13. (c) : Ti(22) : $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^2$

$\therefore$ Order of increasing energy is $3s$, $3p$, $4s$, $3d$.

14. (b): (a) In Balmer series,

$H_{(3\rightarrow2)} > H_{(4\rightarrow2)} > H_{(5\rightarrow2)}$

$\lambda = 656.3\text{ nm}$ 486.1 nm 434.1 nm

(b) In ascending order of wavelength :
Lyman series in UV region < Balmer series in visible region < Paschen series in IR region

(c) $\lambda_{Red} > \lambda_{Yellow} > \lambda_{Blue} > \lambda_{Violet}$

(d) Their wavelengths increase in the order:
Cosmic rays < γ-rays < X-rays.

15. (c) : 1.8 gram of water $= \dfrac{6.023\times10^{23}}{18}\times1.8$

$= 6.023\times10^{22}$ molecules

18 gram of water $= 6.023\times10^{23}$ molecules

18 moles of water $= 18\times6.023\times10^{23}$ molecules

16. (c) : Statement (c) is Gay Lussac's law of gaseous volumes.

17. (d): 1 mole of $P_4 = N_A$ molecules of P_4

$= 4\ N_A$ atoms of $P_4 = 24.092\times10^{23}$ atoms of P_4.

18. (d): Let molar mass be M.

Mass of 21 carbon atoms = 252

% of carbon $= \dfrac{252\times100}{M} = 69.98$

$\therefore$ $M = 360.1$

19. (b): $E_n \propto -\dfrac{Z^2}{n^2}$ $\therefore$ $E_n \propto -Z^2$

Thus, the graph of E *vs* Z^2 is straight line with negative slope.

20. (b)

21. (b): Circumference of 3rd orbit $= 2\pi r_3$

According to Bohr, angular momentum of electron in 3rd orbit is

$mvr_3 = 3\dfrac{h}{2\pi}$ or $\dfrac{h}{mv} = \dfrac{2\pi r_3}{3}$

By de Broglie equation,

$\lambda = \dfrac{h}{mv} \Rightarrow \lambda = \dfrac{2\pi r_3}{3}$ $\therefore$ $2\pi r_3 = 3\lambda$

i.e., circumference of 3rd orbit is three times the wavelength of electron or number of waves made by Bohr electron in one complete revolution in 3rd orbit is three.

22. (b)

23. (c) : In N_2O_3, ratio of mass of O by mass of N

$= \dfrac{48.0\text{ g}}{28.0\text{ g}} = 1.71$

In NO, ratio of mass of O by mass of N

$= \dfrac{16.0\text{ g}}{14.0\text{ g}} = 1.14$

Ratio of masses of oxygen that are combined with 1.08 g of nitrogen in N_2O_3 and NO $= \dfrac{1.71/1.08}{1.14/1.08} = \dfrac{3}{2}$

24. (a) : Mass of 1 mol (6.022×10^{23} atoms) of carbon = 12 g

If Avogadro number is changed to 6.022×10^{20} atoms then mass of 1 mol of carbon

$= \dfrac{12\times6.022\times10^{20}}{6.022\times10^{23}} = 12\times10^{-3}\text{ g}$

25. (b): Higher the value of $(n + l)$ for an orbital, higher is its energy. However, if two different types of orbitals have same value of $(n + l)$, the orbital with lower value of n has lower energy. Therefore, decreasing order of energy of the given orbitals is $5f > 6p > 5p > 4d$.

26. (2.05) : For calculating molarity of the solution we require to know two things, (i) number of moles of urea and (ii) total volume of the solution.

Number of moles of urea dissolved in the solution

$$= \frac{120\text{ g}}{60\text{ g}} = 2$$

Total mass of the solution = 1000 g + 120 g = 1120 g

Volume of the toal solution $= \dfrac{1120\text{ g}}{1.15\text{ g mL}^{-1}}$

= 974 mL = 0.974 L

$$\text{Molarity} = \frac{2}{0.974} = 2.05\text{ M}$$

27. (9): For Li^{2+} ion and H atom in their ground state $n = 1$.

$$\frac{(E_1)_{Li^{2+}}}{(E_1)_H} = \frac{-\dfrac{1312\times(3)^2}{(1)^2}\text{ kJ/mol}}{-\dfrac{1312\times(1)^2}{(1)^2}\text{ kJ/mol}} = 9$$

28. (32.85) : $v = hm\lambda$

$ev = 1/2\ mv^2$

Putting the values we get

$v = 32.85$ volt

29. (5): Given, $\lambda_1 = 108.5\times10^{-7}$ cm; $\lambda_2 = 30.4\times10^{-7}$ cm

Let excited state of He^+ be n_2. It comes from n_2 to n_1 and then n_1 to 1 to emit two successive photons.

$$\frac{1}{\lambda_2} = R_H\times Z^2\left[\frac{1}{1^2} - \frac{1}{n_1^2}\right]$$

$$\frac{1}{30.4\times10^{-7}} = 109678\times4\times\left[\frac{1}{1^2} - \frac{1}{n_1^2}\right]$$

$\therefore \quad n_1 = 2$

For λ_1 ; $n_1 = 2$ and $n_2 = ?$

$$\frac{1}{\lambda_1} = R_H\times Z^2\left[\frac{1}{2^2} - \frac{1}{n_2^2}\right]$$

$$\frac{1}{108.5\times10^{-7}} = 109678\times4\times\left[\frac{1}{2^2} - \frac{1}{n_2^2}\right]$$

$\therefore \quad n_2 = 5$

Thus, excited state for He^+ is 5^{th} orbit.

30. (18) : No. of milliequivalents of acetic acid initially taken = (0.06 N) × (50 mL) = 3 meq

No. of milliequivalents of acetic acid left in the filtrate = (0.042 N) × (50 mL) = 2.1 meq

No. of milliequivalents of acetic acid adsorbed by 3 g of activated charcoal = (3 – 2.1) = 0.9 meq

Amount of acetic acid adsorbed by 3 g of activated charcoal = 0.9 × 60 = 54 mg

Amount of acetic acid adsorbed by 1 g of activated charcoal $= \dfrac{54}{3} = 18$ mg

CBSE warm-up!

CLASS-XI

Chapterwise practice questions for CBSE Exams as per the pattern and marking scheme issued by CBSE for the academic session 2021-22.

Unit 1 Some Basic Concepts of Chemistry | Structure of Atom

Time Allowed : 3 hours **Maximum Marks : 80**

General Instructions : Read the following instructions carefully.

(a) There are 33 questions in this question paper. All questions are compulsory.

(b) Section A : Q. No. 1 to 16 are objective type questions. Q. No. 1 and 2 are passage based questions carrying 4 marks each while Q. No. 3 to 16 carry 1 mark each.

(c) Section B : Q. No. 17 to 25 are short answer questions and carry 2 marks each.

(d) Section C : Q. No. 26 to 30 are short answer questions and carry 3 marks each.

(e) Section D : Q. No. 31 to 33 are long answer questions carrying 5 marks each.

(f) There is no overall choice. However, internal choices have been provided.

(g) Use of calculators and log tables is not permitted.

SECTION-A (OBJECTIVE TYPE)

1. Read the passage given below and answer the following questions :

It may be noted that while using the term mole, it is essential to specify the kind of particles involved. In case of certain substances, it is not clear whether we are talking of 1 mole atom or 1 mole molecule. If we simply say 1 mole of hydrogen, it means we are talking of naturally occurring form of hydrogen *i.e.*, H_2. So, 1 mol of hydrogen means 1 mole of hydrogen molecules. Consequently, to avoid confusion, we must be careful to specify the kind of particles when the term mole is used. For example, one mole of oxygen atoms contains 6.022×10^{23} atoms but one mole of oxygen molecules (O_2) contains 6.022×10^{23} molecules. Therefore, a mole of oxygen molecules is equal to two moles of oxygen atoms. However, if it is not mentioned, then we should consider that it is the natural form of that substance. These days, the molecular forms of hydrogen, nitrogen and oxygen are called dinitrogen (N_2), dihydrogen (H_2) and dioxygen (O_2) respectively to avoid confusion.

The following questions are multiple choice questions. Choose the most appropriate answer.

(i) The total number of atoms in 8.5 g of NH_3 is :

(a) 9.03×10^{23} (b) 3.01×10^{23}

(c) 1.204×10^{23} (d) 6.02×10^{23}

(ii) Which of the following has maximum mass?

(a) 1. 0 mole of H_2 gas

(b) 0.5 mole of sucrose ($C_{12}H_{22}O_{11}$)

(c) 1.2 mole of silver

(d) 22.4 L of N_2 at N.T.P.

(iii) The mass of 10 molecules of naphthalene ($C_{10}H_8$) is

(a) 2.12×10^{-22} g (b) 2.12×10^{-21} g

(c) 2.12×10^{-23} g (d) 1280 g

(iv) Suppose the chemists would have choosen 10^{20} as the number of particles in a mole, the mass of 1 mole of oxygen gas would be

(a) 5.32×10^{-43} g (b) 5.32×10^{-3} g
(c) 5.32×10^{-23} g (d) 5.32×10^{3} g

OR

One million atoms of silver (At. mass = 107.81) atoms weigh

(a) 1.79×10^{-16} g (b) 3.58×10^{-16} g
(c) 3.58×10^{-6} g (d) 1.79×10^{-16} g

2. Read the passage given below and answer the following questions :

A large number of electron orbitals are possible in atom. These can be distinguished by their size, shape and orientation.

To describe each electron in an atom in different orbitals, we need a set of three numbers known as quantum numbers. These are designated as n, l and m_l. In addition to these three numbers another quantum number is also needed which specifies the spin of the electron.

The four quantum numbers provide the following informations about orbitals:

1. n describes the shell, determines the size of the orbital and also to the large extent the energy of the orbital.
2. l determines the subshell and shape of the orbital. There are n subshells in nth shell. To some extent, l also determines the energy of the orbital in a multi-electron atom.
3. m_l designates the orientation of the orbital. For a given value of l, m_l can have $(2l + 1)$ values or number of orbitals. For example, one s-orbital ($l = 0$), three p-orbitals ($l = 1$), five d-orbitals ($l = 2$) per subshell.
4. m_s refers to the orientation of the spin of the electron.

In these questions (Q. No. i-iv), a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choice.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.
(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.
(c) Assertion is correct statement but reason is wrong statement.
(d) Assertion is wrong statement but reason is correct statement.

(i) **Assertion :** The 19th electron in potassium atom enters into 4s-orbital and not in the 3d-orbital.
Reason : $(n + l)$ rule is followed for determining the orbital of lowest energy state.

OR

Assertion : The energy of an electron is largely determined by its principal quantum number.
Reason : The principal quantum number (n) is a measure of the probable distance of finding the electron around the nucleus.

(ii) **Assertion :** For the outermost electron in Na atom, the orbital angular momentum is zero.
Reason : For 3s electron, $l = 0$ and orbital angular momentum is zero.

(iii) **Assertion :** Only principal quantum number determines the energy of an electron in an orbital of Na atom.
Reason : For one electron system, the expression of energy is quite different from that obtained in Bohr's theory.

(iv) **Assertion :** An orbital designated by $n = 3$, $l = 1$ has double dumb-bell shape.
Reason : It belongs to p-subshell.

Following questions (Q. No. 3-11) are multiple choice questions carrying 1 mark each :

3. The ratio of specific charge (e/m) of an electron to that of a hydrogen ion is

(a) 1 : 1 (b) 1840 : 1 (c) 1 : 1840 (d) 2 : 1

4. A gas has a vapour density 11.2. The volume occupied by 1 g of the gas at STP is

(a) 1 L (b) 11.2 L (c) 22.4 L (d) 4 L

OR

Which of the following alkanes has 75% of carbon?

(a) C_2H_6 (b) CH_4 (c) C_3H_8 (d) C_4H_{10}

5. If the speed of an electron in first Bohr orbit of hydrogen be 'x', then speed of the electron in second orbit of He^+ is

(a) $x/2$ (b) $2x$ (c) x (d) $4x$

6. Which of the following is a characteristic property of both mixtures and compounds?

(a) Their properties are same as those of their components.
(b) Energy is released when they are formed.
(c) Their masses are equal to the sum of the masses of their components.
(d) They contain the components in fixed proportions.

OR

Vapour density of a volatile substance is 4 in comparison to methane (CH_4 = 1). Its molecular mass will be

(a) 8 (b) 2 (c) 64 (d) 128

7. Among the various quantum numbers (n, l, m, s) describing an electron, which can have the largest value.

(a) n (b) l (c) m (d) s

OR

In photoelectric effect, the kinetic energy of the photoelectrons increases linearly with the

(a) wavelength of incident light
(b) frequency of incident light
(c) velocity of incident light
(d) atomic mass of the element.

8. Which of the following terms are unitless?

(a) Molality (b) Molarity
(c) Mole fraction (c) Normality

9. The number of radial nodes possible for 3d orbital is

(a) 3 (b) 1 (c) 2 (d) 0

10. 0.6 g of carbon was burnt in air to form CO_2. The number of molecules of CO_2 introduced into air will be :

(a) 6.02×10^{22} (b) 3.01×10^{22}
(c) 6.023×10^{23} (d) 3.01×10^{23}

11. The radial part of wave function depends on the quantum numbers

(a) n, l (b) n only (c) l, m_l (d) l only

In the following questions (Q. No. 12 - 16) a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.
(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.
(c) Assertion is correct statement but reason is wrong statement.
(d) Assertion is wrong statement but reason is correct statement.

12. **Assertion :** Orbital having xz plane as node may be $3d_{xy}$.
Reason : $3d_{xy}$ has zero radial node.

13. **Assertion :** Black body is an ideal body that emits and absorbs radiations of all frequencies.
Reason : The frequency of radiation emitted by a body goes from a lower frequency to higher frequency with an increase in temperature.

OR

Assertion : It is impossible to determine the exact position and exact momentum of an electron simultaneously.
Reason : The path of an electron in an atoms is clearly defined.

14. **Assertion :** Combustion of 16 g of methane gives 18 g of water.
Reason : In the combustion of methane, water is one of the products.

15. **Assertion :** Significant figures for 0.200 is 3 where as for 200 it is 1.
Reason : Zero at the end or right of a number are significant provided they are not on the right side of the decimal point.

16. **Assertion :** An orbital cannot have more than two electrons, moreover, if an orbital has two electrons they must have opposite spins.
Reason : No two electrons in an atom can have same set of all the four quantum numbers.

SECTION-B

The following questions, Q. No. 17 – 25 are short answer type and carry 2 marks each.

17. What is the wavelength and frequency of the limiting line of the Balmer series in the spectrum of hydrogen atom?

OR

Nitrogen laser produces a radiation at a wavelength of 337.1 nm. If the number of photons emitted is 5.6×10^{24}, calculate the power of this laser.

18. The mass of an electron is 9.1×10^{-31} kg. If its kinetic energy is 3.0×10^{-25} J, calculate its wavelength.

19. How many grams of Cl_2 are required to completely react with 0.4 g of H_2 to yield HCl? Also, calculate the amount of HCl formed.

OR

The electric charge on the electron is 1.602×10^{-19} coulomb. How much charge is present on 0.1 mole of Cu^{2+} ions?

20. Calculate the mass percent of calcium, phosphorus and oxygen in calcium phosphate $Ca_3(PO_4)_2$.

OR

The density of 3 molal solution of NaOH is 1.110 g mL^{-1}. Calculate the molarity of the solution.

21. Table–tennis ball has a mass 10 g and a speed of 90 m/s. If speed can be measured within an accuracy of 4% what will be the uncertainty in speed and position?

22. The electronic configuration of valence shell of Cu is $3d^{10}\ 4s^1$ and not $3d^9 4s^2$. How is this configuration explained?

23. A sample of drinking water found to be severely contaminated with chloroform ($CHCl_3$), supposed to be carcinogenic in nature. The level of contamination was 15 ppm (by mass).
    (i) Express this in per cent by mass.
    (ii) Determine the molality of chloroform in the water sample.
    (Given : Molar mass of $CHCl_3 = 119.5\ g\ mol^{-1}$)

24. Write down the values of quantum numbers of all the electrons present in the outermost orbit of argon (At. No. 18).

25. Why does charge-to-mass ratio of positive rays depend on the reside gas in the discharge tube? Why is the charge-to-mass ratio of all cathode rays are same?

SECTION-C

Q. No. 26 - 30 are short answer type II carrying 3 marks each.

26. Which hydrogen-like ion has the wavelength difference between the first lines of Balmer and Lyman series equal to 59.3 nm ($R_H = 109678\ cm^{-1}$)?

OR

Calculate : (i) First excitation energy of the electron in the hydrogen atom.
(ii) Ionisation energy of the hydrogen atom.

27. The relative density of a mixture of nitrogen and oxygen is 14.4 and the relative densities of nitrogen and oxygen are 14.0 and 16.0 respectively. Calculate the composition of the mixture (i) by volume and (ii) by mass.

OR

If 4 g of NaOH dissolves in 36 g of H_2O, calculate the mole fraction of each component in the solution. Also, determine the molarity of solution (specific gravity of solution is $1\ g\ mL^{-1}$).

28. (a) What is limiting reagent?
    (b) Oxygen is prepared by catalytic decomposition of potassium chlorate ($KClO_3$). Decomposition of potassium chlorate gives potassium chloride (KCl) and oxygen (O_2). If 2.45 mol of oxygen is needed for an experiment, how many grams of potassium chlorate must be decomposed?

29. A photon of wavelength 4×10^{-7} m strikes on metal surface, the work function of the metal being 2.13 eV. Calculate (i) the energy of the photon (eV) (ii) the kinetic energy of the emission and (iii) the velocity of the photoelectron ($1\ eV = 1.602 \times 10^{-19}\ J$).

30. Aluminium oxide contains 52.9% Al and carbon dioxide contains 27.27% C. Calculate the percentage of Al in aluminium carbide assuming that the law of reciprocal proportions is true.

SECTION-D

Q. No. 31 - 33 are long answer type carrying 5 marks each.

31. Three moles of N_2 combines with five moles of H_2 to form NH_3 by Haber's process.
    (i) What is the limiting reagent?
    (ii) Calculate the grams of the reactant left in the container.
    (iii) How many moles of NH_3 are produced?
    (iv) How many litres of NH_3 are produced at STP?

OR

    (a) What is the S.I. unit of mass? How is it defined?
    (b) Round up the following upto three significant figures :
    (i) 34.216, (ii) 10.4107, (iii) 0.04597, (iv) 2808
    (c) Chlorine is prepared in the laboratory by treating manganese dioxide (MnO_2) with aqueous hydrochloric acid according to the reaction

$$4HCl_{(aq)} + MnO_{2(s)} \rightarrow 2H_2O_{(l)} + MnCl_{2(aq)} + Cl_{2(g)}$$

How many grams of HCl react with 5.0 g of manganese dioxide?

32. (a) What is meant by dual nature of light? Calculate the wavelength (in angstroms) associated with an electron travelling at a speed of 2.19×10^6 m/s.
    (b) Electromagnetic radiation of wavelength 242 nm is just sufficient to ionise the sodium atom. Calculate the ionisation energy of sodium in $kJ\ mol^{-1}$.

OR

    (a) A metal surface of threshold frequency $5.3 \times 10^{14}\ s^{-1}$ is exposed to a photon of radiation having energy 3.5×10^{-19} J. Will it exhibit photoelectric effect?
    (b) Point out the angular momentum of an electron in (i) 4*s*-orbital, (ii) 3*p*-orbital, (iii) 4th orbit.?

33. (i) The average molar mass of a mixture of methane (CH_4) and ethene (C_2H_4) present in the ratio of $a : b$ is found to be $20.0\ g\ mol^{-1}$. If the ratio were reversed, what would be the molar mass of the mixture?

(ii) 4 g carbon were heated with 8 g of sulphur. How much carbon disulphide (CS_2) will be formed when the reaction is complete? What will be its percentage purity?

OR

(a) What is the difference in expressing a weight of a solid as 36.5×10^3 g and 36.50×10^3 g.

(b) A compound (molecular mass = 246) has the following data:

Element	% Composition	Relative no. of atoms
A	9.76	0.406
B	13.01	0.406
C	26.01	1.625
D	51.22	2.846

From the data find out

(i) atomic masses of the elements *A*, *B*, *C* and *D*,

(ii) simple ratio,

(iii) molecular formula for the compound.

SOLUTIONS

1. (i) (a) : Moles of $NH_3 = \frac{8.5}{17} = 0.5 = 0.5$

No. of H atoms $= 0.5 \times 6.022 \times 10^{23} \times 3$
$= 9.03 \times 10^{23}$ atoms.

(ii) (b)

(iii) (b) : Molar mass of $C_{10}H_8 = 10 \times 12 + 8 \times 1 = 128$

Mass of 10 molecules of $C_{10}H_8 = \frac{128}{6.02 \times 10^{23}} \times 10$

$= 2.12 \times 10^{-21}$ g

(iv) (b) : $\frac{32 \times 10^{20}}{6.02 \times 10^{23}} = 5.32 \times 10^{-3}$ g

OR

(a) : $\frac{107.81}{6.02 \times 10^{23}} \times 10^6 = 1.79 \times 10^{-16}$ g

2. (i) (a) : K (19) : $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^1$
$(n + l)$ rule is followed to determine the lowest energy state.

OR

(a)

(ii) (a) : Na(11) : $1s^2, 2s^2, 2p^6, 3s^1$
for *s* orbital $l = 0$
so, orbital angular momentum is zero.

(iii) (d)

(iv) (d) : Orbital designated by $n = 3$, $l = 1$ is $3p$ orbital which have dumb-bell shape.

3. (b)

4. (a) : Molar mass $= 2 \times 11.2 = 22.4$ g

Volume of 1 g compound at STP $= \frac{22.4}{22.4} = 1$ L

OR

(b) : Percentage of carbon in methane

$= \frac{12}{16} \times 100 = 75\%$

5. (c) : $v_n = \frac{v_1 \times Z}{n} = \frac{x \times 2}{2} = x$

6. (c)

OR

(c) : Vapour density is related with molecular mass as,
Molar mass = 2 × vapour density
Now, methane (CH_4) molar mass = 16

So, vapour density $= \frac{16}{2} = 8$

Here, relative vapour density for the substance is four times that of methane $= 8 \times 4 = 32$
Hence, molar mass of the substance $= 2 \times 32 = 64$

7. (a)

OR

(b) : $K.E. = h\nu - h\nu_0$

8. (c)

9. (d) : No. of nodes $= n - l - 1 = 3 - 2 - 1 = 0$

10. (b) : $C + O_2 \longrightarrow CO_2$
12 g of C gives $CO_2 = 44$ g

0.6 g of C will give $CO_2 = \frac{44}{12} \times 0.6 = 2.2$ g

Moles of $CO_2 = \frac{2.2}{44} = 0.05$

No. of molecules $= 0.05 \times 6.02 \times 10^{23}$
$= 3.01 \times 10^{22}$

11. (a) **12. (b)**

13. (b) : The ideal body, which emits and absorbs radiation of all frequencies, is called a black body and the radiation emitted by such a body is called black body radiation. The exact frequency distribution of the emitted radiation from a black body depends only on its temperature. At a given temperature, Intensity of radiation emitted increases with decreases of wavelength, reaches a maximum value at a given wavelength and then starts decreasing with further decrease of wavelength.

OR

(c)

14. (d)

15. (c) : Zero at the end or right of number are significant provided they are on the right side of the decimal point, For example, 0.200 g has three significant figures.

16. (b)

17. For the Balmer series $n_L = 2$. As n_H gets larger and approaches infinity ($n_H \rightarrow \infty$), $\frac{1}{n_H^2}$ gets smaller and smaller and approaches zero. So, for limiting line, $n_H = \infty$

$$\bar{\nu} = \frac{1}{\lambda} = 1.097 \times 10^7 \left(\frac{1}{2^2} - \frac{1}{\infty^2}\right) = 1.097 \times 10^7 \times \frac{1}{4}\,m^{-1}$$

$$\lambda = \frac{4}{1.097 \times 10^7}\,m = 3.64 \times 10^{-7}\,m = 364\ nm$$

$$\nu = \frac{c}{\lambda} = \frac{3.0 \times 10^8\,m\,s^{-1}}{3.64 \times 10^{-7}\,m} = 8.24 \times 10^{14}\ s^{-1}$$

OR

$$E = Nh\nu = \frac{Nhc}{\lambda}$$

$$= \frac{(5.6 \times 10^{24}) \times (6.62 \times 10^{-34}\,Js) \times (3.0 \times 10^8\,ms^{-1})}{337.1 \times 10^{-9}\,m}$$

$= 3.3 \times 10^6$ J.

18. $K.E. = \frac{1}{2}mv^2 \Rightarrow v = \left(\frac{2\,K.E.}{m}\right)^{1/2}$

$$= \left(\frac{2 \times 3.0 \times 10^{-25}\ kg\,m^2\,s^{-2}}{9.1 \times 10^{-31}\ kg}\right)^{1/2} = 812\ m\,s^{-1}$$

$$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34}\ J\,s}{(9.1 \times 10^{-31}\ kg)(812\ m\,s^{-1})}$$

$= 8967 \times 10^{-10}$ m $= 896.7$ nm

19. $\underset{(2 \times 1 = 2)}{H_{2(g)}} + \underset{(2 \times 35.5 = 71)}{Cl_{2(g)}} \longrightarrow 2HCl_{(g)}$

Now, 2 g of H_2 react with 71 g of Cl_2 to give 73 g of HCl

So, 0.4 g of H_2 will react with $\frac{71}{2} \times 0.4 = 14.2$ g of Cl_2

$\Rightarrow$ 14.2 g of Cl_2 reacts to give $\frac{73 \times 0.4}{2} = 14.6$ g of HCl

Therefore, 14.2 g of Cl_2 are required to completely react with 0.4 g of H_2 to yield 14.6 g of HCl.

OR

Charge on one mole of electrons

$= 6.02 \times 10^{23} \times 1.602 \times 10^{-19}$ coulomb

$= 96440$ coulomb

≈ 96500 coulomb $= 1$ Faraday

Charge on one mole of Cu^{2+} ions

$= 2 \times 96500$ coulomb $= 2$ Faraday

Charge on 0.1 mole of Cu^{2+} ions $= 0.1 \times 2 = 0.2$ Faraday

20. Molecular mass of $Ca_3(PO_4)_2$

$= 3 \times 40 + 2(31 + 4 \times 16) = 310$

Mass of Ca $= 3 \times 40 = 120$

$$\text{Mass percentage of Ca} = \frac{120}{310} \times 100 = 38.71$$

Mass of P $= 2 \times 31 = 62$

$$\text{Mass percentage of P} = \frac{62}{310} \times 100 = 20\%$$

Mass of O $= 8 \times 16 = 128$

$$\text{Mass percentage of O} = \frac{128}{310} \times 100 = 41.29\%$$

OR

3 molal solution of NaOH means that 3 mol of NaOH are dissolved in 1000 g of solvent.

Mass of solute $= 3 \times 40 = 120$ g

$\therefore$ Mass of solution = Mass of Solvent + mass of Solute

$= 1000$ g $+ 120$ g

$= 1120$ g

Density of solution $= 1.110\ g\,mL^{-1}$

$$\text{Volume of solution} = \frac{1120}{1.110}\,mL$$

$= 1009.00$ mL

$$\text{Molarity} = \frac{\text{Moles of solute}}{\text{Vol. of solution (in mL)}} \times 1000$$

$$= \frac{3}{1009} \times 1000 = 2.97M.$$

21. Uncertainty in speed of ball $= \frac{90 \times 4}{100} = 3.6\ ms^{-1}$

Uncertainty in position, $\Delta x = \frac{h}{4\pi m \Delta v}$

$$= \frac{6.626 \times 10^{-34}\,Js}{4 \times 3.14 \times 10 \times 10^{-3}\ kg \times 3.6\ ms^{-1}} = 1.46 \times 10^{-33}\ m$$

22. This is because completely filled and half filled orbitals have extra stability. In $3d^{10}4s^1$, *d*-orbitals are completely filled and hence this configuration is more stable.

23. (i) 15 ppm means 15 g of $CHCl_3$ is present in 106 g of solution.

Since, 106 g of solution contain 15 g of $CHCl_3$.

Therefore, 100 g of solution contain $\frac{15}{10^6} \times 100$

$= 15 \times 10^{-4}\ \% = 1.5 \times 10^{-3}\ \%$

(ii) $m = \frac{w_B}{M_B} \times \frac{1000}{w_A} = \frac{15}{119.5} \times \frac{1000}{10^6}$

[$\because$ Mass of solvent = Mass of solution – Mass of solute $= 10^6 - 15 \approx 10^6$]

$= 1.26 \times 10^{-4}$ mol/kg

24. The electronic configuration of argon is
$1s^2, 2s^2 2p^6, 3s^2 3p_x^2 3p_y^2 3p_z^2$
Values of quantum numbers are :

	n	*l*	*m*	*s*
$3s^2$	3	0	0	+1/2, – 1/2
$3p_x^2$	3	1	±1	+1/2, – 1/2
$3p_y^2$	3	1	±1	+1/2, – 1/2
$3p_z^2$	3	1	0	+1/2, – 1/2

25. The positive rays are actually positively charged ions (not protons, unless the gas in the discharge tube is hydrogen). When the charge to mass ratio is measured the mass of the moving positive charge will be the mass of the nucleus of whatever gas is in the discharge tube. Cathode rays are made up of electrons and all electrons have same charge-to-mass ratio. That's why charge to mass ratio of all cathode rays is same.

26. Wavelength of 1st line in Balmer series,

$$\frac{1}{\lambda_B} = Z^2 R_H \left[\frac{1}{2^2} - \frac{1}{3^2}\right] = \frac{5}{36} R_H Z^2 \text{ or } \lambda_B = \frac{36}{5R_H Z^2}$$

Wavelength of 1st line in Lyman series is,

$$\frac{1}{\lambda_L} = Z^2 R_H \left[\frac{1}{1^2} - \frac{1}{2^2}\right] \text{ or } \lambda_L = \frac{4}{3 \times R_H Z^2}$$

Difference : $\lambda_B - \lambda_L = 59.3 \times 10^{-7}$

$$= \frac{36}{5R_H Z^2} - \frac{4}{3R_H Z^2} = \frac{1}{R_H Z^2}\left[\frac{36}{5} - \frac{4}{3}\right]$$

$$Z^2 = \frac{88}{59.3 \times 10^{-7} \times 109678 \times 15} = 9.0 \text{ or, } Z = 3$$

Therefore, hydrogen-like species is Li^{2+}.

OR

The energy of the electron in the n^{th} shell of hydrogen atom is given by

$$E_n = -\frac{2\pi^2 me^4}{n^2 h^2} = \frac{1.312 \times 10^6}{n^2} \text{ J mol}^{-1}$$

(i) First excitation energy is the amount of energy required to excite the electron from $n = 1$ (ground state) to $n = 2$ (first excited state),

$$\Delta E = E_2 - E_1 = -\frac{1.312 \times 10^6}{2^2} - \left(-\frac{1.312 \times 10^6}{1^2}\right)$$

$= -3.28 \times 10^5 + 13.12 \times 10^5 \text{ J mol}^{-1}$
$= + 9.84 \times 10^5 \text{ J mol}^{-1}$

(ii) Ionisation energy is the amount of energy required to remove the electron from $n = 1$ to $n = \infty$, *i.e.*,
$\Delta E = E_\infty - E_1 = 0 - (-1.312 \times 10^6) = + 1.312 \times 10^6 \text{ J mol}^{-1}$

27. (i) Let 1 mL of the mixture contain x mL of N_2 and $(1 - x)$ mL of O_2.

Mass of x mL of $N_2 = 14.0 \times x = 14\ x$ g ($\because$ Mass = $d \times V$)
Mass of $(1 - x)$ mL of $O_2 = 16.0 \times (1 - x) = (16.0 - 16x)$ g
Total mass of mixture = $14x + 16.0 - 16x$
So, $14x + 16.0 - 16x = 14.4 \times 1 = 14.4$
or $x = 0.8$, *i.e.*, 80% by volume
Oxygen = $1 - x = (1 - 0.8) = 0.2$, *i.e.*, 20% by volume.

(ii) Let 1 g of the mixture contain x g of N_2 and $(1 - x)$ g of oxygen.

$$\text{Volume of } x \text{ g of } N_2 = \frac{x}{14.0} \qquad \left(\because V = \frac{\text{Mass}}{\text{Density}}\right)$$

$$\text{Volume of } (1 - x) \text{ g of } O_2 = \frac{(1-x)}{16.0}$$

$$\text{Total volume of the mixture} = \frac{x}{14.0} + \frac{(1-x)}{16.0}$$

$$\text{So, } \frac{x}{14.0} + \frac{(1-x)}{16.0} = \frac{1}{14.4}$$

or $x = 0.7778$, *i.e.*, 77.78% by mass
Oxygen = $(1 - x) = (1 - 0.7778) = 0.2222$
i.e., 22.22% by mass.

OR

$$4 \text{ g NaOH} = \frac{4}{40} \text{ mole} = 0.1 \text{ mole}$$

$$36 \text{ g } H_2O = \frac{36}{18} \text{ mole} = 2 \text{ mole}$$

$$\therefore \text{ Mole fraction of NaOH} = \frac{0.1}{0.1 + 2} = 0.047$$

Mole fraction of $H_2O = 1 - 0.047 = 0.953$

$$\text{or } \frac{2}{2 + 0.1} = 0.95$$

Total mass of solution = Mass of solvent + Mass of solute
= 36 + 4 g = 40 g

$$\text{Volume of solution} = \frac{\text{Mass}}{\text{Sp. gravity}} = \frac{40 \text{ g}}{1 \text{g mL}^{-1}}$$

= 40 mL = 0.040 L

$$\text{Molarity of solution} = \frac{\text{Moles of solute}}{\text{Volume of solution in L}}$$

$$= \frac{0.1 \text{ mole}}{0.040 \text{ L}} = 2.5 \text{ M}$$

28. (a) It is the reagent which is entirely consumed when reaction goes to completion.

(b) $2KClO_{3(s)} \rightarrow 2KCl_{(s)} + 3O_{2(g)}$
Molecular weight of $KClO_3$
$= 39 + 35.5 + 3 \times 16 = 122.5 \text{ g mol}^{-1}$
For 3 moles of O_2 we need = 2×122.5 g of $KClO_3$

$$\text{For 2.4 moles of } O_2 \text{ we need} = \frac{2 \times 122.5}{3} \times 2.4$$

= 196 g of $KClO_3$

29. (i) Energy of the photon $(E) = h\nu = \frac{hc}{\lambda}$

$$= \frac{(6.626\times10^{-34}\ \text{J s})\times(3\times10^{8}\ \text{m s}^{-1})}{4\times10^{-7}\ \text{m}} = 4.97\times10^{-19}\ \text{J}$$

$$= \frac{4.97\times10^{-19}}{1.602\times10^{-19}}\ \text{eV} = 3.10\ \text{eV}$$

(ii) Kinetic energy of emission $\left(\frac{1}{2}mv^2\right)$

$= h\nu - h\nu_0 = 3.10 - 2.13 = 0.97$ eV

(iii) $\frac{1}{2}mv^2 = 0.97\ \text{eV} = 0.97\times1.602\times10^{-19}$ J

i.e., $\frac{1}{2}\times(9.11\times10^{-31}\ \text{kg})\times v^2 = 0.97\times1.602\times10^{-19}$ J

or, $v^2 = 0.341\times10^{12} = 34.1\times10^{10}$ or $v = 5.84\times10^{5}\ \text{m s}^{-1}$

30. In aluminium oxide, aluminium is 52.9% and oxygen is 100 – 52.9 = 47.1%. In CO_2, C is 27.27% and oxygen is 100 – 27.27 = 72.73%.

72.73 g oxygen combines with 27.27 g C

∴ 47.10 g oxygen combines with $\frac{27.27\times47.1}{72.73}$

$= 17.66$ g C

The ratio of masses of Al and C which combine with a fixed mass, *i.e.*, 47.10 g of oxygen is 52.9 : 17.66, *i.e.*, 3 : 1. Therefore, the mass of aluminium carbide is 52.90 + 17.62 = 70.52 g

∴ 70.52 g of Aluminium carbide contain 52.9 g Al.

100 g of Aluminium carbide contain $52.9\times\frac{100}{70.52}$

$= 75.01$ g

Thus, percentage of Al in aluminium carbide is 75.01%.

31. $\underset{1\ \text{mol}}{N_{2(g)}} + \underset{3\ \text{mol}}{3H_{2(g)}} \longrightarrow \underset{2\ \text{mol}}{2NH_{3(g)}}$

So, 3 moles of N_2 will combine with 9 moles of H_2, but there are only 5 moles of H_2. H_2 is the reactant which is present in less quantity than required so.

(i) H_2 is the limiting reagent.

(ii) N_2 is left in the container.

3 moles of H_2 combine with 1 mole N_2

∴ 1 moles of H_2 combine with 1/3 mole N_2 and 5 moles of H_2 will combine with $1/3\times5 = 1.66$ moles of N_2 So, moles of N_2 left unreacted = 3 – 1.66

$= 1.34$ moles N_2

1 mole of N_2 = 28 g N_2

∴ 1.34 moles $N_2 = 28\times1.34 = 37.52$ g N_2

(iii) Number of moles of product formed depends on the limiting reagent.

3 moles of H_2 = 2 moles of NH_3

∴ 5 moles of $H_2 = 2/3\times5 = 3.33$ moles of NH_3.

So, 3.33 moles of NH_3 are produced.

(iv) 1 mole of any gas at STP occupies 22.4 L in volume.

∴ 3.33 moles of NH_3 at STP will occupy $22.4\times3.33 = 74.6$ L volume.

OR

(a) The S.I. unit of mass is kilogram. The amount of matter present in a substance is called mass. The unit of mass (kilogram) is defined as being equal to the mass of international prototype of the kilogram.

(b) (i) 34.2 (ii) 10.4 (iii) 0.0460 (iv) 2.81×10^3

(c) $\underset{\substack{4\ \text{mole}\\ \text{or } 146\ \text{g}}}{4HCl_{(aq)}} + \underset{\substack{1\ \text{mole}\\ \text{or } 87\ \text{g}}}{MnO_{2(s)}} \rightarrow 2H_2O_{(l)} + MnCl_{2(aq)} + Cl_{2(g)}$

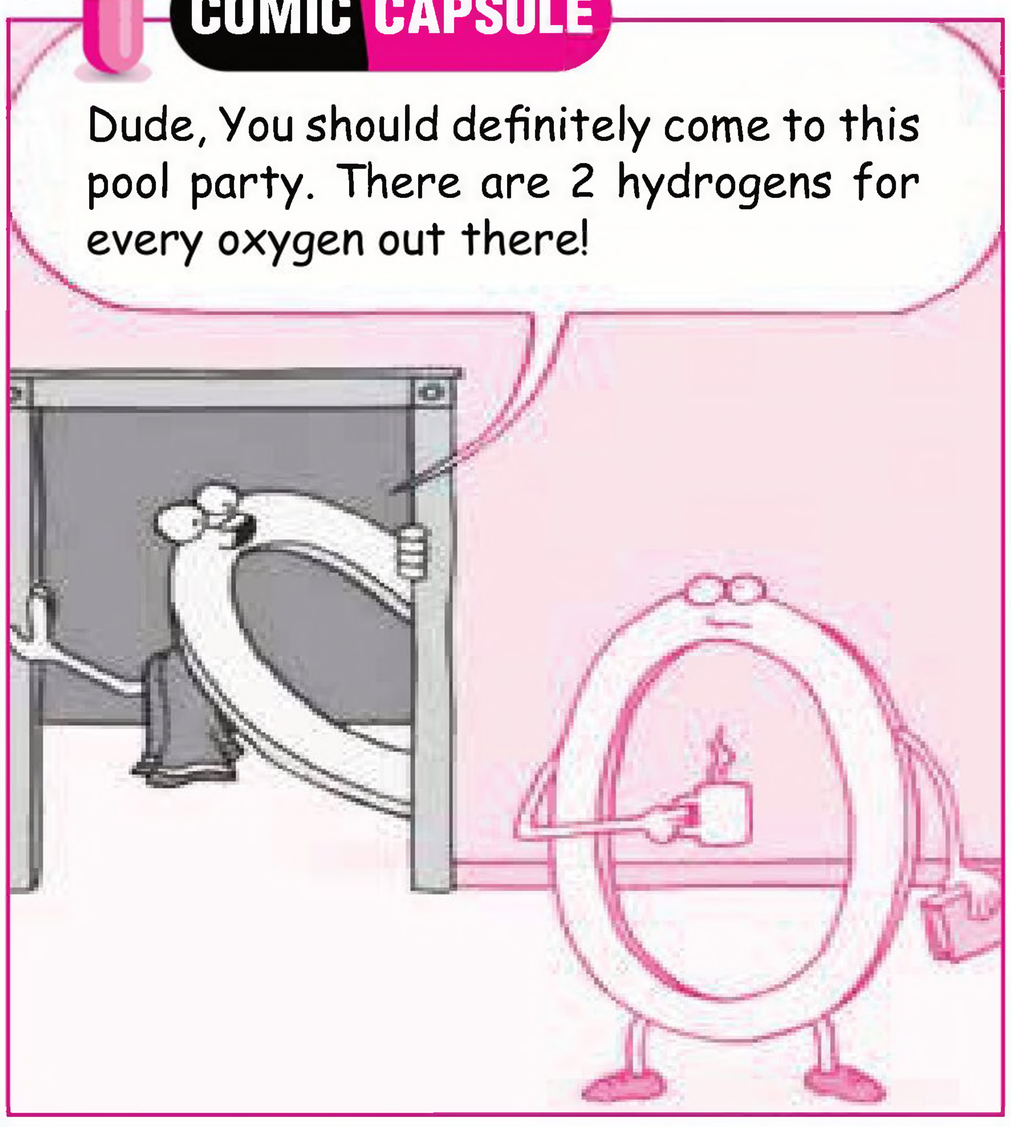
87 g of MnO_2 reacts with HCl = 146 g

5 g of MnO_2 reacts with $HCl = \frac{146\times5}{87} = 8.39 \approx 8.40$ g

32. (a) Light has a dual nature. Sometimes it behaves like a particle (called a photon), which explains how light travels in straight line. The particle nature of light was explained by Einstein in the photoelectric effect. Sometimes it behaves like a wave, which explains how light bends (or diffracts) around an object. The wave nature of light was first illustrated through experiments on diffraction and interference. Like all electromagnetic waves, light can travel through vacuum.

Scientists accept the evidence that supports this dual nature of light.

COMIC CAPSULE



$$\lambda = \frac{h}{mv} = \frac{6.62 \times 10^{-34}\ \text{kg m}^{-2}\text{s}^{-1}}{9.11\times10^{-31}\,\text{kg} \times 2.19\times10^{6}\,\text{ms}^{-1}}$$

$= 3.318 \times 10^{-10}$ m = 3.32 Å

(b) Here, $\lambda = 242$ nm $= 242 \times 10^{-9}$ m

$$I.E. = \frac{hc}{\lambda} = \frac{6.626\times10^{-34}\times3\times10^{8}}{242\times10^{-9}}$$

$= 8.214 \times 10^{-19}$ J/atom

Ionisation energy of sodium in kJ mol^{-1}

$= 8.214 \times 10^{-19} \times 10^{-3} \times 6.022 \times 10^{23} = 494.65$ kJ mol^{-1}

OR

(a) $\nu = \frac{E(\text{Photon})}{h} = \frac{3.5\times10^{-19}}{6.625\times10^{-34}} = 5.28 \times 10^{14}\ \text{s}^{-1}$

Since the frequency of the radiation used $\nu < \nu_0$, *i.e.*, threshold frequency or minimum frequency to show photoelectric effect, it will not show photoelectric effect.

(b) Angular momentum of the electron in an orbital $= \frac{h}{2\pi}\sqrt{[l(l+1)]}$

(i) $l = 0$ for 4*s*-orbital, $\therefore$ Angular momentum = 0

(ii) $l = 1$ for 3*p*-orbital, $\therefore$ Angular momentum $= \frac{h}{\sqrt{2}\pi}$

(iii) Angular momentum in an orbit $= \frac{nh}{2\pi}$

$n = 4$ for 4$^{\text{th}}$ orbit

$\therefore$ Angular momentum $= \frac{2h}{\pi}$

33. (i) Molar mass of $CH_4 = 16$ g mol^{-1}

Molar mass of $C_2H_4 = 28$ g mol^{-1}

When they are present in the ratio $a : b$, their average

molar mass $= \frac{a\times16+b\times28}{a+b} = 20$ g mol^{-1} (given)

i.e., $16a + 28b = 20(a + b)$

or $4a + 7b = 5(a + b)$ or $a = 2b$ or $\frac{a}{b} = \frac{2}{1} = 2 : 1$

If the ratio is reversed, now the ratio $a : b = 1 : 2$

$\therefore$ Average molar mass $= \frac{1\times16+2\times28}{1+2}$

$= \frac{16+56}{3} = \frac{72}{3} = 24$ g mol^{-1}

(ii)

C	+ 2S	$\rightarrow$	CS_2
12 g	2 × 32 = 64 g		12 + 2 × 32 = 76 g

Obviously, sulphur will be the limiting reagent.

8 g sulphur will produce $CS_2 = \frac{76}{64} \times 8 = 9.5$ g

Carbon reacted $= \frac{12}{64} \times 8 = 1.5$ g

Carbon left = 4 – 1.5 = 2.5 g

Total mass of products = 9.5 + 2.5 = 12 g

$\therefore$ % purity of CS_2 in the products $= \frac{9.5}{12} \times 100 = 79.2\%$

OR

(a) 36.5 × 10^3 g has three significant figures while 36.50 × 10^3 has four significant figures. Hence 36.50 represents greater accuracy than 36.5.

(b) **Step 1 :** To calculate the atomic masses :

The relative number of atoms

$= \frac{\text{Percentage of element}}{\text{Atomic mass}}$

$\text{Atomic mass} = \frac{\text{Percentage of element}}{\text{Relative number of atoms}}$

Atomic mass of $A = \frac{9.76}{0.406} = 24$

Atomic mass of $B = \frac{13.01}{0.406} = 32$

Atomic mass of $C = \frac{26.01}{1.625} = 16$

Atomic mass of $D = \frac{51.22}{2.846} = 18$

Step - II : To calculate the simple ratio of atoms.

Element	Relative no. of atoms	Simple atomic ratio
A	0.406	$\frac{0.406}{0.406} = 1$
B	0.406	$\frac{0.406}{0.406} = 1$
C	1.625	$\frac{1.625}{0.406} = 4$
D	2.846	$\frac{2.846}{0.406} = 7$

Thus, the atomic ratio of $A : B : C : D$ is 1 : 1 : 4 : 7.

Hence, the empirical formula = ABC_4D_7.

Step-III : Calculation of molecular formula.

Empirical formula mass = 24 + 32 + 4 × 16 + 7 × 18 = 246

$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}} = \frac{246}{246} = 1$

Molecular formula of compound = $(ABC_4D_7)_1 = ABC_4D_7$

MONTHLY TEST DRIVE

This specially designed column enables students to self analyse their extent of understanding of specified chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

Total Marks : 120 **Organic Chemistry - Some Basic Principles and Techniques** **Time Taken : 60 Min.**

NEET

Only One Option Correct Type

1. The IUPAC name of $H_2N-\overset{\overset{O}{\|}}{C}-CH_2-COOH$ is

(a) 3-amino-3-oxopropanoic acid
(b) 3-amidopropanoic acid
(c) 2-amidoethanoic acid
(d) 2-carbamoylethanoic acid.

2. During the hearing of a court case, the judge suspected that some changes in the documents had been carried out. He asked the forensic department to check the ink used at two different places. According to you which technique can give the best results?

(a) Column Chromatography
(b) Solvent extraction
(c) Distillation
(d) Thin-layer chromatography

3. The correct order of increasing stability of the following carbanions is

$\underset{I}{CH_2=CH\bar{C}H_2}$ $\underset{II}{CH_2=\bar{C}H}$ $\underset{III}{(CH_3)_3\bar{C}}$ $\underset{IV}{Ph_3\bar{C}}$ $\underset{V}{\bar{C}H_3}$

(a) III < V < II < IV < I
(b) II < III < V < IV < I
(c) II < III < V < I < IV
(d) III < V < II < I < IV

4. Tautomerism is exhibited by

(a) $(CH_3)_3CNO$ (b) $(CH_3)_2NH$
(c) R_3CNO_2 (d) RCH_2NO_2

5. In which of the following two carbon atoms are differently hybridised?

$\underset{I}{CH_2=\overset{+}{C}H}$ $\underset{II}{CH_3\bar{C}HCH_3}$ $\underset{III}{CH_2=\bar{C}H}$

$\underset{IV}{CH\equiv\bar{C}}$ $\underset{V}{\dot{C}(CH_3)_3}$

(a) I only (b) II and V
(c) III only (d) I and V

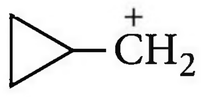
6. The Lassaigne's extract of an organic compound after acidification with HNO_3 is mixed with a few mL of CCl_4 and then treated with chlorine water. The lower layer of CCl_4 develops a violet colour. This indicates that the organic compound contains

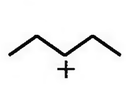
(a) nitrogen (b) sulphur
(c) bromine (d) iodine.

7. Organic compound of the molecular formula $C_2H_2Br_2$ can exist in how many isomeric forms?

(a) 1 (b) 2 (c) 3 (d) 4

8. Which of the following is not stabilised by hyperconjugation?

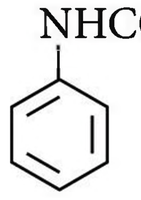
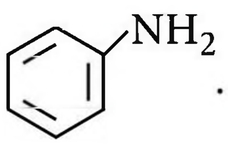
(a) $CH_3-\overset{+}{C}H_2$ (b) 

(c)  (d) 

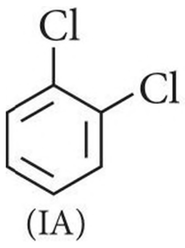
9. Which one of the following has all the effects, namely inductive, mesomeric and hyperconjugative?

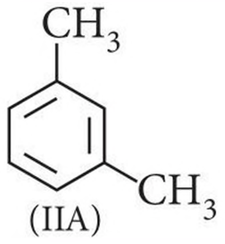
(a) CH_3Cl
(b) $CH_3CH=CH_2$
(c) $CH_3CH=CH\overset{\overset{O}{\|}}{C}CH_3$
(d) $CH_2=CH-CH=CH_2$

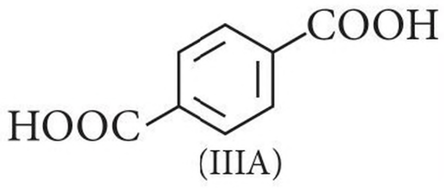
10. The number of isomers (geometrical and optical) possible for the compound with the following structure $CH_3CH = CH - CH = CH - CH_2CHOHCH_3$ is
(a) 2 (b) 4 (c) 6 (d) 8

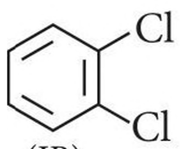
11. Which of the following statements is incorrect?
(a) The *meta*-position in nitrobenzene undergoes electrophilic substitution reaction because it is less deactivated when compared to *ortho* and *para* positions in nitrobenzene.
(b) The *meta*-position in phenol is more electron rich than the *meta*-position in nitrobenzene.
(c) The benzene ring in  is slightly deactivated than the benzene ring in  .
(d) $\overset{+}{C}F_3$ is less stable than $CF_3\overset{+}{C}H_2$.

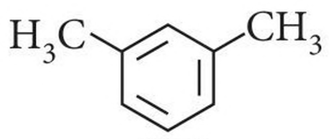
12. Consider the following pairs of possible isomers

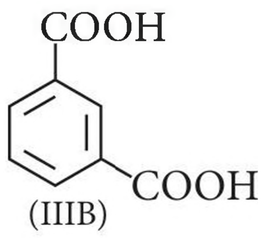

(IA)


(IIA)


(IIIA)


(IB)


(IIB)

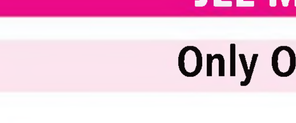
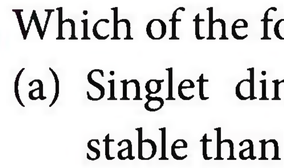

(IIIB)

Which of the following statements is correct?
(a) All three pairs represent different compounds.
(b) IA and IB are identical; IIA and IIB are identical; and IIIA and IIIB are identical.
(c) IA and IB are isomers; IIA and IIB are identical; and IIIA and IIIB are isomers.
(d) IA and IB are identical; IIA and IIB are identical, and IIIA and IIIB are isomers.

Assertion & Reason Type

Directions : In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as :
(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

13. **Assertion :** Lithium is not used in Lassaigne's test.
Reason : Lithium generally forms covalent compounds.

14. **Assertion :**  is more stable than 
Reason : Compound in which the positive and negative charges reside on the most electropositive and most electronegative atoms of the species respectively is more stable.

15. **Assertion :** Heterolytic fission of $CH_3CH_2CH_3$ gives $CH_3\overset{+}{C}H_2$ and CH_3^-.
Reason : $CH_3\overset{+}{C}H_2$ is more stable than $\overset{+}{C}H_3$, but $CH_3CH_2^-$ is less stable than CH_3^-.

JEE MAIN / JEE ADVANCED

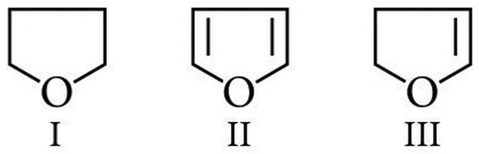
Only One Option Correct Type

16. Which of the following statements is correct?
(a) Singlet dimethylcarbene $[(CH_3)_2C{:}]$ is more stable than the triplet $[(CH_3)_2\dot{C}]$.
(b) Singlet difluorocarbene $[F_2C{:}]$ is less stable than the corresponding triplet.
(c) Singlet carbene resembles free diradical while triplet carbene resembles a carbocation.
(d) None of these.

17. Dichlorocarbene is generated by the action of potassium-1-butoxide on chloroform. This is an example of
(a) α-elimination reaction
(b) β-elimination reaction
(c) addition reaction
(d) rearrangement reaction.

18. In the following groups
(I) – OAc
(II) –OMe
(III) – OSO_2Me
(IV) – OSO_2CF_3
the order of leaving group ability is
(a) I > II > III > IV
(b) IV > III > I > II
(c) III > II > I > IV
(d) II > III > IV > I

19. Arrange the following in decreasing order of solubility in water.



(a) I > III > II

(b) III > II > I

(c) II > III > I

(d) All are equally soluble

More than One Options Correct Type

20. Which of the following compounds contain all the carbon atoms in the same hybridisation state?

(a) $H-C\equiv C-C\equiv C-H$

(b) $CH_3-C\equiv C-CH_3$

(c) $CH_2=C=CH_2$

(d) $CH_2=CH-CH=CH_2$

21. Which of the following statement(s) is/are correct?

(a) HCN and HNC are functional isomers.

(b) HCN and HNC are tautomers.

(c) $R-CN$ and $R-NC$ are functional isomers.

(d) R_3N^+ shows – *I* effect.

22. Which of the following statements are correct?

(a) A *meso* compound is optically active because the rotation caused by any molecules is cancelled by an equal and opposite rotation caused by another molecules that is the mirror image of the first.

(b) A *meso* compound has chiral centres but exhibits no optical activity.

(c) A *meso* compound has a plane of symmetry and thus exhibits no optical activity.

(d) A *meso* compound has molecules which are superimposable on their mirror image even though they contain chiral centres.

23. Which of the following have zero dipole moment?

(a) *p*-Dichlorobenzene

(b) Benzene-1, 4-diol

(c) Fumaric acid

(d) Maleic acid

Integer / Numerical Value Type

24. In a compound C, H and N are present in 9 : 1 : 3.5 by weight. If molecular weight of the compound is 108, the number of N atoms present in the molecular formula will be

25. 0.50 g of an organic compound was Kjeldahlished. The ammonia evolved was passed in 50 cm^3 of 1 N H_2SO_4. The residual acid required 60 cm^3 of N/2 NaOH solution. Calculate the percentage of nitrogen in the compound.

26. Deep violet coloured complex formed when sodium extract of the organic compound containing sulphur is treated with sodium nitroprusside has the formula $Na_2[Fe(CN)_xNOS]$. The value of *x* is

Comprehension Type

Hyperconjugation is a general stabilising interaction. It involves delocalisation of *s*-electrons of C—H bond

3 Amazing Facts You Must Know

Why Do Fresh Eggs Sink, and Rotten Eggs Float?

A classical trick to know whether we can still eat an egg (if they are fresh enough) is putting them in a bowl of water. If the egg sinks, it means that it is still denser than water, which is the natural state if they are still fresh.

As decomposition takes place, solid and liquid matter is transformed into gas. Gaseous pressure builds up, and since the egg shell is porous, this gas starts escaping. This loss of mass, eventually leads to the density of the egg being lower than water. This makes the egg float. This represents an easy way to tell if an egg has undergone too much decomposition to be eaten (if it is rotten).

What's the Role of Ethylene in Fruit Ripening?

Ethylene is a gas that acts as a growth hormone for plants. It can be released by plants and fruits, and at the same time, it regulates processes such as aging or ripening. Ripening is basically the set of changes that fruit undergoes over time: generally softening, and changes of color or texture. These changes can be triggered by ethylene. An example of a fruit that produces a lot of ethylene are bananas. This is why storing other fruits near bananas, will make them ripen faster.

What Happens if You Clean Your Hands with Bleach?

When you make alkalies as lye react with fatty acids, you get soap. If you use alkalies, such as bleach to wash your hands, something similar is happening. You are turning the fatty acids in your hands into soap, making your hands weirdly smooth and slippery. Now you are turning your hands into soap!

of an alkyl group directly attached to an atom of unsaturated system or to an atom with an unshared *p*-orbital. The *s*-electrons of C—H bond of the alkyl group enter into partial conjugation with the attached unsaturated system or with the unshared *p*-orbital. Hyperconjugation is a permanent effect.

27. Hyperconjugation involves delocalisation of _____.

(a) electrons of carbon-hydrogen σ bond of an alkyl group directly attached to an atom of the unsaturated system.

(b) electrons of carbon-oxygen σ bond of alkyl group directly attached to the positively charged carbon atom.

(c) π-electrons of carbon-carbon bond

(d) lone pair of electrons

28. Number of hyperconjugation structures in isopropyl radical is _____.

(a) 3

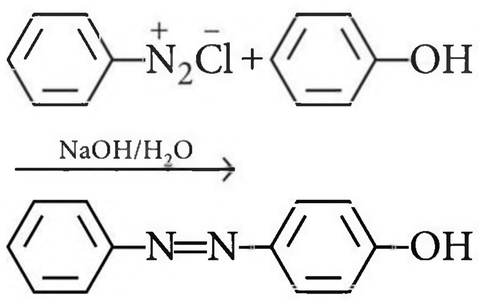
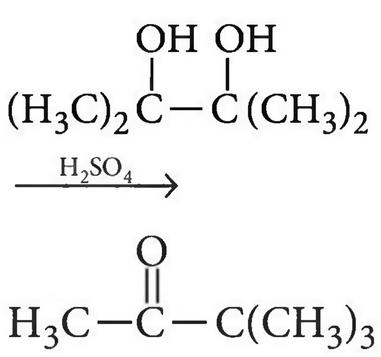
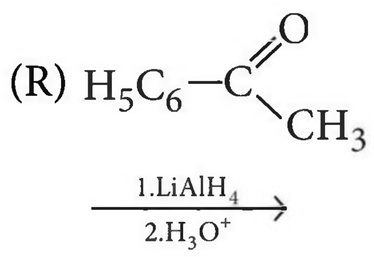
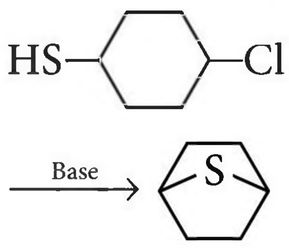
(b) 6

(c) 9

(d) 12

Matrix Match Type

29. Match the reaction in Column I with appropriate options in Column II.

Column I	Column II
(P) 	1. Racemic mixture
(Q) 	2. Addition reaction
(R) 	3. Substitution reaction
(S) 	4. Coupling reaction
	5. Carbocation intermediate

	P	Q	R	S
(a)	3, 2	5, 1	1, 3	2
(b)	2, 4	5, 3	3	4
(c)	3, 4	5	1, 2	3
(d)	4, 5	1,4	3, 2	1

30. Match the phenomena given in List I with their descriptions given in List II and select the correct answer using the code given below the lists :

List I	List II
P. Inductive effect	1. Delocalisation of σ electrons with π-bond
Q. Resonance	2. Strong effect
R. No bond resonance	3. Permanent effect
S. Electromeric effect	4. Delocalisation of π-electrons

	P	Q	R	S
(a)	1	4	3	2
(b)	4	3	1	2
(c)	3	4	1	2
(d)	1	4	3	2

Keys are published in this issue. Search now! ☺

SELF CHECK

No. of questions attempted .....
No. of questions correct .....
Marks scored in percentage .....

Check your score! If your score is

> 90%	EXCELLENT WORK !	You are well prepared to take the challenge of final exam.
90-75%	GOOD WORK !	You can score good in the final exam.
74-60%	SATISFACTORY !	You need to score more next time.
< 60%	NOT SATISFACTORY!	Revise thoroughly and strengthen your concepts.

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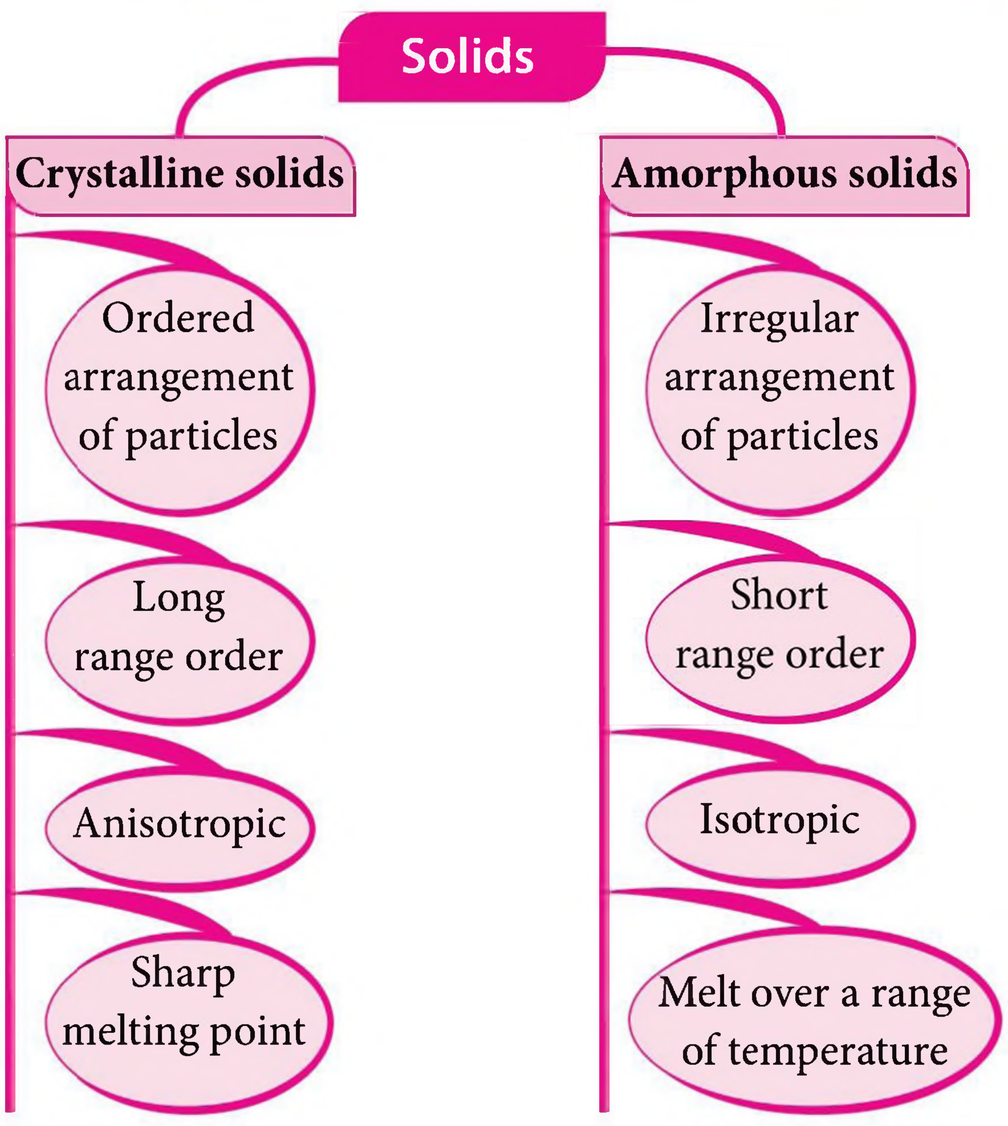
Unit 1

The Solid State | Solutions

The Solid State

The *solid state* represents the physical state of matter in which constituents have no translatory motion although vibratory or rotational motions are possible about their position in solid lattice.

Classification of Solids



Types of Crystalline Solids

Ionic solids

Constituent particles : Ions of opposite charge
Binding forces : Electrostatic forces

Covalent solids

Constituent particles : Atoms
Binding forces : Covalent bonds

Molecular solids

Constituent particles : Molecules
Binding forces : van der Waals forces

Metallic solids

Constituent particles : Kernels and electrons
Binding forces : Metallic bonds

Bragg's Law

When a beam of *X*-rays of wavelength λ, strikes a crystal surface, the maximum intensity of reflected rays occur when

$$\sin\theta = \frac{n\lambda}{2d} \quad \text{or} \quad n\lambda = 2d\sin\theta \qquad \text{(Bragg's equation)}$$

It helps in the determination of crystal structure.

Crystal Systems and Bravais Lattices

On the basis of primitives or axial distances and interfacial angles of a unit cell, there are seven crystal systems and fourteen Bravais lattices.

Crystal systems	Unit cell dimensions and angles	Bravais lattices	Examples
Cubic (most symmetrical)	$a = b = c$; $\alpha = \beta = \gamma = 90°$	Primitive, Body centred, Face centred	Cu, Zinc blende, KCl, NaCl
Orthorhombic	$a \neq b \neq c$; $\alpha = \beta = \gamma = 90°$	Primitive, Body centred, End centred, Face centred	Rhombic sulphur, KNO_3, $BaSO_4$
Tetragonal	$a = b \neq c$; $\alpha = \beta = \gamma = 90°$	Primitive, Body centred	Sn(White tin), SnO_2, TiO_2, $CaSO_4$
Monoclinic	$a \neq b \neq c$; $\alpha = \gamma = 90° \neq \beta$	Primitive, End centred	Monoclinic sulphur, $PbCrO_4$, $Na_2SO_4 . 10H_2O$
Rhombohedral	$a = b = c$; $\alpha = \beta = \gamma \neq 90°$	Primitive	$CaCO_3$ (Calcite), HgS (Cinnabar)
Triclinic (most unsymmetrical)	$a \neq b \neq c$; $\alpha \neq \beta \neq \gamma \neq 90°$	Primitive	$K_2Cr_2O_7$, $CuSO_4 \cdot 5H_2O$, H_3BO_3
Hexagonal	$a = b \neq c$; $\alpha = \beta = 90°$; $\gamma = 120°$	Primitive	Graphite, ZnO, CdS

Packing in Solids

Simple cubic packing

- No. of particles (Z) = 1
- *AAA* … type arrangement
- Packing efficiency = 52.4%
- C.No. = 6

Body centred cubic packing

- No. of particles (Z) = 2
- Slightly open square close packing in first layer. In second layer, spheres are on the top of hollows. Third layer is exactly over the first layer and so on.
- Packing efficiency = 68%
- C.No. = 8

Face centred cubic packing

- No. of particles (Z) = 4
- *ABCABC* … type arrangement
- Packing efficiency = 74%
- C.No. = 12

Hexagonal close packing

- No. of particles (Z) = 6
- *ABAB* … type arrangement
- Packing efficiency = 74%
- C.No. = 12

Voids

If N is the number of close packed spheres, then

- number of octahedral voids generated = N
- number of tetrahedral voids generated = $2N$

In *ccp* or *fcc*, total no. of voids per unit cell = 12

In *hcp*, total no. of voids per unit cell = 18

Calculations Involving Unit Cell Parameters

$$\text{Density of unit cell } (\rho) = \frac{Z \times M}{N_0 \times a^3}$$

Limiting Radius Ratio, Coordination Number and Geometry

r_+/r_-	C. No.	Geometry
< 0.155	2	Linear
0.155 - 0.225	3	Trigonal planar
0.225 - 0.414	4	Tetrahedral
0.414 - 0.732	6	Octahedral
0.732 - 1.000	8	Cubic (body centred)

Imperfections in Solids

Imperfections/ Defects in Solids

Point defects
Deviations from ideal arrangement around a point or an atom.

Line defects
Deviations from ideal arrangement in entire rows of lattice points.

Stoichiometric/Intrinsic/Thermodynamic defects
Do not disturb stoichiometry of solids.

- **Vacancy defect :** Arises when lattice sites are vacant. Decreases density, shown by non-ionic solids.
- **Interstitial defect :** Arises when constituent particles occupy interstitial site. Increases density, shown by non-ionic solids.
- **Frenkel defect :** Smaller ion (usually cation) dislocates from its normal site to an interstitial site. Does not change density, shown by ionic solids, *e.g.*, ZnS, AgCl, AgBr, AgI, etc.
- **Schottky defect :** Arises when equal number of cations and anions are missing. Decreases density, shown by ionic solids, *e.g.*, NaCl, KCl, CsCl, AgBr, etc.

Impurity defects
Arise when foreign atoms are present at lattice sites *e.g.*, $SrCl_2$ in NaCl, $CdCl_2$ in AgCl, etc.

Non-stoichiometric defects
Disturb stoichiometry of solids.

Metal excess defect

- **Due to anionic vacancies**
  A negative ion is missing from its lattice site, leaving a 'hole' which is occupied by an electron to maintain electrical neutrality, *e.g.*, LiCl, NaCl.
- **Due to presence of extra cations**
  Usually arises when metal oxides are heated, *e.g.*, ZnO.

Metal deficiency defect
Arises when metal shows variable valency *e.g.*, Fe^{2+}, Fe^{3+}.

Electrical Properties

Electrical Properties

Conductors
Conductivity range : 10^4 to 10^7 ohm^{-1} m^{-1}

Insulators
Conductivity range : 10^{-20} to 10^{-10} ohm^{-1} m^{-1}

Semiconductors
Conductivity range : 10^{-6} to 10^4 ohm^{-1} m^{-1}

- ***n*-type semiconductors :** Group 14 element like Si or Ge doped with group 15 elements like P or As etc., free electrons increase conductivity.
- ***p*-type semiconductors :** Group 14 elements like Si or Ge doped with group 13 element like B, Al or Ga, holes increase conductivity.

Magnetic Properties

Magnetic Properties	Paramagnetic	Diamagnetic	Ferromagnetic	Ferrimagnetic	Antiferromagnetic
	Contains atleast one unpaired electron in the orbital thus, weakly attracted by the magnetic field *e.g.*, O_2, Cu^{2+}.	All electrons are paired and orbitals are completely filled thus, weakly repelled by the magnetic field. *e.g.*, NaCl, H_2O.	Unpaired electrons in same direction thus, strongly attracted by the magnetic fields and can be permanently magnetised. *e.g.*, Ni.	Unequal no. of parallel and anti-parallel arrangement of magnetic moments thus, have small net magnetic moment *e.g.*, Fe_3O_4.	Equal number of domains in opposite direction thus, no net magnetic moment. *e.g.*, MnO.

Dielectric Properties

Dielectrical Properties

Piezoelectricity : The electricity produced when mechanical stress is applied on polar crystals *e.g.*, $PbZrO_3$, $NH_4H_2PO_4$ and quartz.

Pyroelectricity : The electricity produced when some polar crystals are heated. *e.g.*, Crystals of tartaric acid.

Ferroelectricity : In some piezoelectric crystals, the dipoles are permanently polarized even in the absence of electric field. However, on applying electric field, the direction of polarization changes. *e.g.*, $BaTiO_3$, KH_2PO_4, Rochelle salt.

Anti-ferroelectricity : In some piezoelectric crystals, the dipoles in alternate polyhedra point up and down so, that the crystal does not possess any net dipole moment. *e.g.*, $PbZrO_3$.

Solutions

Solution and its Types

- *Solution* is a perfectly homogeneous mixture (having number of phases equal to one) of two or more components.
- **Different Types of Binary Solutions**

S.No.	Solute	Solvent	Example
1.	Solid	Solid	Alloy
2.	Solid	Liquid	Sugar solution in water
3.	Solid	Gas	Iodine vapours in air
4.	Liquid	Solid	Hydrated salt
5.	Liquid	Liquid	Ethanol in water
6.	Liquid	Gas	Water vapours in air
7.	Gas	Solid	Dissolved gases in minerals
8.	Gas	Liquid	Aerated drinks
9.	Gas	Gas	Air

- *Solubility* of a substance is its maximum amount that can be dissolved in a specified amount of solvent at a specified temperature.
- **Factors affecting solubility of a solid in a liquid :**
  - **Nature of solute and solvent :** Polar solutes dissolve in polar solvents and non-polar solutes in non-polar solvents. (*i.e.*, like dissolves like).
  - **Effect of temperature :**
    - If the dissolution process is endothermic ($\Delta_{sol}H > 0$), the solubility increases with rise in temperature.
    - If dissolution process is exothermic ($\Delta_{sol}H < 0$) the solubility decreases with rise in temperature.
  - **Effect of pressure** : Pressure does not have any significant effect on solubility of solids in liquids as these are highly incompressible.
- **Factors affecting solubility of a gas in a liquid :**
  - **Effect of pressure :** Henry's law states that "the partial pressure of the gas in vapour phase (p) is proportional to the mole fraction of the gas (x) in the solution" $p = K_H x$.

    Higher the value of K_H at a given pressure, the lower is the solubility of the gas in the liquid.
  - **Effect of temperature :** As dissolution is an exothermic process, then according to Le Chatelier's Principle, the solubility should decrease with increase of temperature.

Methods for Expressing Concentration of Solutions

Mass percentage, $\left(\frac{w}{W}\right)\% = \frac{w_2}{(w_1 + w_2)} \times 100$

Volume percentage, $\left(\frac{v}{V}\right)\% = \frac{V_2}{(V_1 + V_2)} \times 100$

Mass by volume percentage, $\left(\frac{w}{V}\right)\% = \frac{w_2}{V_{\text{solution}}\,(\text{in mL})} \times 100$

Strength $(\text{g L}^{-1}) = \frac{w_2\,(\text{in g})}{V_{\text{solution}}\,(\text{in mL})} \times 1000$

Mass fraction, $\left(\frac{w}{W_{\text{total}}}\right) \Rightarrow x_1 = \frac{w_1}{w_1 + w_2}$ or $x_2 = \frac{w_2}{w_1 + w_2}$

Parts per million (ppm) $= \frac{w_2}{(w_1 + w_2)} \times 10^6$

Molarity, (M) $(\text{mol L}^{-1}) = \frac{w_2 \times 1000}{M_2 \times V_{\text{solution}}\,(\text{in mL})}$

Molality, (m) $(\text{mol kg}^{-1}) = \frac{w_2 \times 1000}{M_2 \times w_1\,(\text{in g})}$

Normality, (N) $(\text{g-eq L}^{-1}) = \frac{w_2 \times 1000}{E_2 \times V_{\text{solution}}\,(\text{in mL})}$

Demal, $(D) = \frac{w_2 \times 1000}{M_2 \times V_{\text{solution}}\,(\text{in mL})}$ (at 0°C)

Mole fraction, $(x) \Rightarrow x_1 = \frac{n_1}{n_1 + n_2}$ or $x_2 = \frac{n_2}{n_1 + n_2}$, and $x_1 + x_2 = 1$

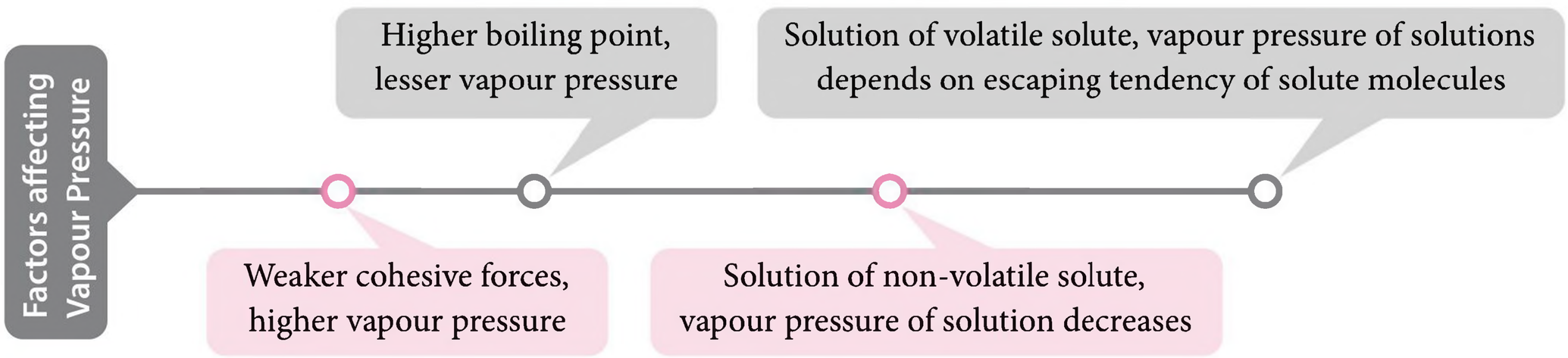
Formality, $(F) = \frac{\text{No. of gram formula mass of solute}}{\text{Volume of solution (in L)}}$

Vapour Pressure

Vapour pressure is the pressure exerted by the vapours over the solution when it is in equilibrium state at a given temperature.

$$\log \frac{P_2}{P_1} = \frac{\Delta_{vap}H}{2.303R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right] \qquad \text{(Clausius–Clapeyron equation)}$$

where P_1 and P_2 are the vapour pressures at temperatures T_1 and T_2 respectively.



Raoult's law states that for a solution of volatile liquids, the partial vapour pressure of each component of the solution is directly proportional to its mole fraction in the solution.

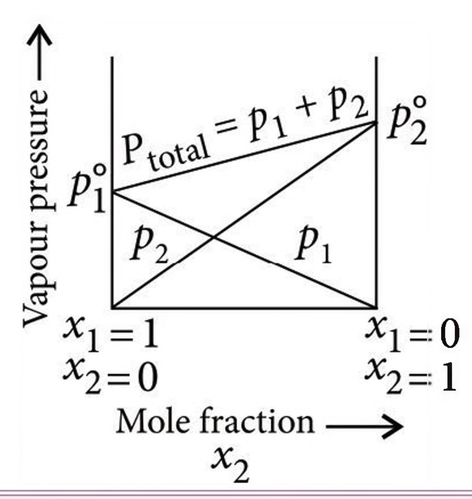
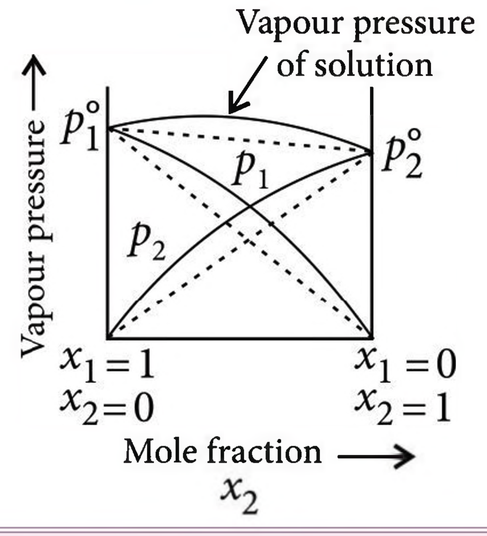
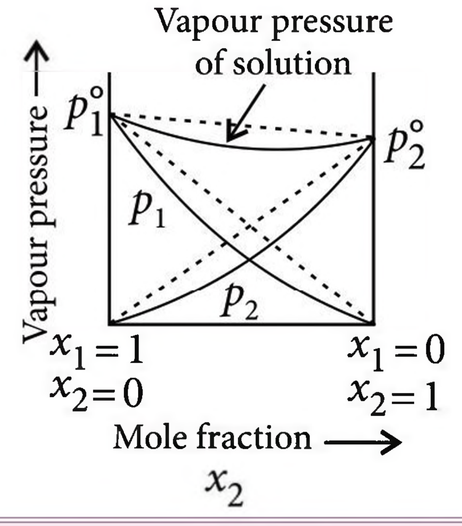
For component 1, $p_1 = p_1^\circ x_1$

For component 2, $p_2 = p_2^\circ x_2$

$$P_{\text{total}} = p_1 + p_2 = x_1 p_1^\circ + x_2 p_2^\circ = p_1^\circ + (p_2^\circ - p_1^\circ)x_2$$

where p_1° and p_2° are the vapour pressures of pure components 1 and 2 respectively.

Ideal and Non-ideal Solutions

Ideal solutions	Non-ideal solutions	
	Positive deviation from Raoult's law	Negative deviation from Raoult's law
		
$A - B$ interactions $\approx$ $A - A$ and $B - B$ interactions	$A - B$ interactions << $A - A$ and $B - B$ interactions	$A - B$ interactions >> $A - A$ and $B - B$ interactions
$\Delta H_{mix} = 0, \Delta V_{mix} = 0$	$\Delta H_{mix} > 0, \Delta V_{mix} > 0$	$\Delta H_{mix} < 0, \Delta V_{mix} < 0$
e.g., dilute solution, benzene + toluene, *n*-hexane + *n*-heptane	*e.g.*, acetone + ethanol, acetone + CS_2, water + methanol	*e.g.*, acetone + aniline, acetone + chloroform, $CH_3OH + CH_3COOH$

Azeotropes

Azeotropes have the same composition in liquid and vapour phase and boil at a constant temperature. Their components cannot be separated by fractional distillation. Minimum boiling azeotropes show a large positive deviation from Raoult's law *e.g.*, ethanol-water mixture. Maximum boiling azeotropes show a large negative deviation from Raoult's law *e.g.*, nitric acid-water mixture.

Colligative Properties

These properties depend only on the number of solute particles and not on its nature.

Colligative Properties

Relative Lowering of Vapour Pressure

$$\frac{p_1^\circ - p_1}{p_1^\circ} = x_2 = \frac{n_2}{n_1 + n_2} = \frac{n_2}{n_1} = \frac{w_2 \times M_1}{M_2 \times w_1}$$

($\because$ for dilute solutions, $n_2 << n_1$)

Depression in Freezing Point

$\Delta T_f = T_f^\circ - T_f$; $\Delta T_f \propto m$ or $\Delta T_f = K_f m$

$$= K_f \left(\frac{w_2 \times 1000}{M_2 \times w_1 (\text{in g})} \right)$$

K_f is known as freezing point depression constant or molal depression constant or Cryoscopic constant, having unit K kg mol^{-1}.

Elevation in Boiling Point

$\Delta T_b = T_b - T_b^\circ$;

$$\Delta T_b \propto m \text{ or } \Delta T_b = K_b m = K_b \left(\frac{w_2 \times 1000}{M_2 \times w_1 (\text{in g})} \right)$$

K_b is called boiling point elevation constant or molal elevation constant or Ebullioscopic constant, having unit K kg mol^{-1}.

Osmotic Pressure

$$\pi = CRT = \left(\frac{n_2}{V} \right) RT,$$

$$\pi V = \frac{w_2 RT}{M_2} \text{ or } M_2 = \frac{w_2 RT}{\pi V}$$

VAN'T HOFF FACTOR

- It is defined as the ratio of the experimental value of the colligative property to the calculated value of the colligative property.

$$i = \frac{\text{Observed value of the colligative property}}{\text{Calculated value of the colligative property}}$$

$$i = \frac{\text{Calculated molecular mass}}{\text{Observed molecular mass}}$$

$$i = \frac{\text{Total number of moles of particles after association / dissociation}}{\text{Total number of moles of particles before association / dissociation}}$$

$$\alpha_{\text{dissociation}} = \frac{i-1}{n-1}$$

$$\alpha_{\text{association}} = \frac{1-i}{1-\frac{1}{n}}$$

- For substances undergoing association or dissociation in the solution, the various expressions for the colligative properties are modified as follows :

$$\frac{p_1^\circ - p_1}{p_1^\circ} = ix_2; \qquad \Delta T_b = iK_b m$$

$$\Delta T_f = iK_f m; \qquad \pi = iCRT$$

WRAP it up!

1. The melting point of RbBr is 682°C, while that of NaF is 988°C. The principal reason that melting point of NaF is much higher than that of RbBr is that
   (a) the two crystals are not isomorphous
   (b) the molar mass of NaF is smaller than that of RbBr
   (c) the internuclear distance $r_c + r_a$ is greater for RbBr than for NaF
   (d) the bond in RbBr has more covalent character than the bond in NaF.

2. Which one of the following gases has the lowest value of Henry's law constant ?
   (a) N_2 (b) He (c) H_2 (d) CO_2

3. An aqueous solution is 1.00 molal in KI. Which change will cause the vapour pressure of the solution to increase ?
   (a) Addition of NaCl
   (b) Addition of Na_2SO_4
   (c) Addition of 1.00 molal KI
   (d) Addition of water

4. In KBr crystal structure, the second-nearest neighbour of K^+ ions is ..... and its number is .....
   (a) Br^-, 6 (b) Br^-, 12 (c) K^+, 6 (d) K^+, 12

5. The solubility of gases in liquids (water) is favoured by
   (a) increase in both pressure and temperature
   (b) decrease in both pressure and temperature
   (c) increase in pressure and decrease in temperature
   (d) decrease in pressure and increase in temperature

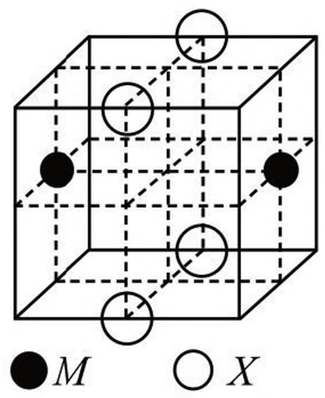
6. Iron exhibits *bcc* structure at room temperature. Above 900 °C, it transforms to *fcc* structure. The ratio of density of iron at room temperature to that at 900 °C (assuming molar mass and atomic radii of iron remains constant with temperature) is
   (a) $\frac{\sqrt{3}}{\sqrt{2}}$ (b) $\frac{4\sqrt{3}}{3\sqrt{2}}$ (c) $\frac{3\sqrt{3}}{4\sqrt{2}}$ (d) $\frac{1}{2}$
   (NEET 2018)

7. A metal crystallises into two cubic phases, face centred cubic (*fcc*) and body centred cubic (*bcc*). Whose unit lengths are 3.5 and 3.0 Å respectively. The ratio of densities of *fcc* and *bcc* is
   (a) 1.259 (b) 2.513 (c) 0.892 (d) 1.862

8. If *A* contains 2% NaCl and is separated by a semipermeable membrane from *B* which contains 10% NaCl, then which event will occur?
   (a) NaCl will flow from *A* and *B*
   (b) NaCl will flow from *B* to *A*
   (c) Water will flow from *A* to *B*
   (d) Water will flow from *B* to *A*

9. The empty space in *hcp* unit cell is
   (a) 74% (b) 47.6% (c) 32% (d) 26%

10. The cubic unit cell structure of a compound containing cation *M* and anion *X* is shown below. When compared to the anion, the cation has smaller ionic radius. Choose the correct statement(s).



(a) The empirical formula of the compound is *MX*.
(b) The cation *M* and anion *X* have different coordination geometries.
(c) The ratio of *M*–*X* bond length to the cubic unit cell edge length is 0.866.
(d) The ratio of the ionic radii of cation *M* to anion *X* is 0.414. **(JEE Advanced 2020)**

11. At 100°C, copper (Cu) has *fcc* unit cell structure with cell edge length of *x* Å. What is the approximate density of Cu (in g cm^{-3}) at this temperature?

(a) $\frac{205}{x^3}$ (b) $\frac{211}{x^3}$ (c) $\frac{105}{x^3}$ (d) $\frac{422}{x^3}$

(JEE Main 2019)

12. When mercuric iodide is added to the aqueous solution of KI, then the;
(a) freezing point is raised
(b) freezing point is lowered
(c) freezing point does not change
(d) boiling point does not change

13. Potassium metal crystallizes in a face-centred arrangement of atoms where the edge of the unit cell is 0.574 mm. Determine the shortest separation of any two potassium nuclei
(a) 0.4059 mm (b) 0.6029 mm
(c) 0.0201 mm (d) 0.2561 mm

14. In a face centred cubic lattice, atom *A* occupies the corner positions and atom *B* occupies the face centre positions. If one atom of *B* is missing from one of the face centred points, the formula of the compound is
(a) A_2B (b) AB_2 (c) A_2B_2 (d) A_2B_5

15. Consider the following statements:
1. Isotonic solutions have the same molar concentration at a given temperature
2. The molal elevation constant K_b is a characteristic of a solvent and is independent of the solute added
3. The freezing point of a 0.1 M KCl solution is more than that of 0.1 M aqueous $AlCl_3$ solution.

Choose the correct statements.
(a) 1 and 2 (b) 2 and 3
(c) 1 and 3 (d) 1, 2 and 3

16. Sodium crystallizes in a body-centred cubic unit cell (*bcc*) with edge length 4.29 Å. What is the radius of the sodium atom ?
(a) 6.33 Å (b) 1.86 Å (c) 0.59 Å (d) 0.21 Å

17. AgCl is crystallized from molten AgCl containing a little $CdCl_2$. The solid obtained will have
(a) cationic vacancies equal to number of Cd^{2+} ions incorporated
(b) cationic vacancies equal to double the number of Cd^{2+} ions
(c) anionic vacancies
(d) neither cationic nor anionic vacancies.

18. Silver crystallises in *fcc* lattice. If edge length of the cell is 4.077×10^{-8} cm and density is 10.5 g cm^{-3}, calculate the atomic mass of silver.
(a) 100.21 (b) 103.60 (c) 107.14 (d) 110.19

19. An aqueous solution of a salt MX_2 at certain temperature has a van't Hoff factor of 2. The degree of dissociation for this solution of the salt is :
(a) 0.50 (b) 0.33 (c) 0.67 (d) 0.80

20. MgO has a structure of NaCl, the coordination number of O^{2-} in MgO is
(a) 6 (b) 3 (c) 12 (d) 8

21. Determination of the molar mass of acetic acid in benzene using freezing point depression is affected by:
(a) partial ionization (b) dissociation
(c) complex formation (d) association

18+

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AVAXHOME-

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22. The correct order of osmotic pressure of 0.01 M aqueous solution of the following is
(a) Sucrose > CH_3COOH > KCl
(b) CH_3COOH > Sucrose > KCl
(c) Sucrose > KCl > CH_3COOH
(d) KCl > CH_3COOH > Sucrose

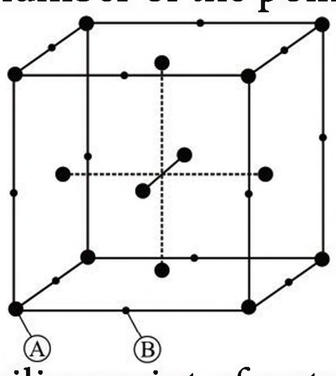
23. Lattice defect per 10^{15} NaCl is 1. What is the number of lattice defects in a mole of NaCl?
(a) 6.02×10^{23} (b) 6.02×10^{8}
(c) 10^{14} (d) None of these

24. For an ideal solution, the correct option is
(a) $\Delta_{mix}G = 0$ at constant T and P
(b) $\Delta_{mix}S = 0$ at constant T and P
(c) $\Delta_{mix}\ V \neq 0$ at constant T and P
(d) $\Delta_{mix}\ H = 0$ at constant T and P. **(NEET 2019)**

25. At 35 °C, the vapour pressure of CS_2 is 512 mm Hg and that of acetone is 344 mmHg. A solution of CS_2 in acetone has a total vapour pressure of 600 mmHg. The false statement amongst the following is
(a) heat must be absorbed in order to produce the solution at 35°C
(b) a mixture of 100 mL CS_2 and 100 mL acetone has a volume < 200 mL
(c) CS_2 and acetone are less attracted to each other than to themselves
(d) Raoult's law is not obeyed by this system.

Integer/Numerical Value Type

26. For a solid with the following structure, the coordination number of the point *B* is



27. The normal boiling point of water is 373 K. Vapour pressure of water at temperature T is 19 mm Hg. If enthalpy of vaporisation is 40.67 kJ/mol, then temperature T would be
(Use : log 2 = 0.3, R : 8.3 $JK^{-1}\ mol^{-1}$) :

28. The density of solid argon is 1.65 g/mL at –233°C. If the argon atom is assumed to be sphere of radius 1.54×10^{-8} cm, what percentage of solid argon is apparently empty space? (At. wt. of Ar = 40)

29. The vapour pressure of an aqueous solution of sucrose at 373 K is found to be 750 mm Hg. The molality of the solution at the same temperature will be:

30. In $Fe_{0.93}O$, the % of Fe^{+++} ions is

SOLUTIONS

1. **(c) :** This leads to stronger coulombic forces of attractions in NaF.

2. **(d):** According to Henry's law the mass of a gas dissolved per unit volume of solvent is proportional to the pressure of the gas at constant temperature $m = k.p$ *i.e.*, as the solubility increases, value of Henry's law constant decreases. Since CO_2 is most soluble in water among the given set of gases. Therefore CO_2 has the lowest value of Henry's law constant.

3. **(d):** When the aqueous solution of one molal KI is diluted with water, concentration decreases, therefore the vapour pressure of the resulting solution increases.

4. **(d):** The first nearest neighbour of K^+ ion will be 6 Br^- ions at a distance of $\frac{a}{2}$ whereas the second nearest neighbours will be 12 K^+ ions at a distance of $\frac{a\sqrt{2}}{2}$.

5. **(c) :** Dissolution of gases in liquids is generally an exothermic process accompanied by a large decrease in volume. Follow Le chatelier's principle.

6. **(c) :** For *bcc* lattice : $Z = 2,\ a = \frac{4r}{\sqrt{3}}$

For *fcc* lattice : $Z = 4,\ a = 2\sqrt{2}\,r$

$$\therefore \quad \frac{d_{R.T.}}{d_{900°C}} = \frac{\left(ZM/\ N_A a^3\right)_{bcc}}{\left(ZM/\ N_A a^3\right)_{fcc}}$$

Given, molar mass and atom radii are constant.

$$= \frac{2}{4}\left(2\sqrt{2}r \Big/ \frac{4r}{\sqrt{3}}\right)^3 = \frac{3\sqrt{3}}{4\sqrt{2}}$$

7. **(a) :** Density of *fcc* $= \frac{Z_1 \times \text{At. mass}}{N_A V_1}$ and

Density of *bcc* $= \frac{Z_2 \times \text{At. mass}}{N_A V_2}$

$$\frac{d_{fcc}}{d_{bcc}} = \frac{Z_1}{Z_2} \times \frac{V_2}{V_1}$$

MONTHLY TEST DRIVE CLASS XI ANSWER KEY

1.	(d)	2.	(d)	3.	(d)	4.	(d)	5.	(d)
6.	(d)	7.	(c)	8.	(b)	9.	(c)	10.	(d)
11.	(d)	12.	(d)	13.	(a)	14.	(a)	15.	(a)
16.	(d)	17.	(a)	18.	(b)	19.	(a)	20.	(a,d)
21.	(a,b,c,d)	22.	(b,c)	23.	(a,c)	24.	(2)	25.	(56)
26.	(6)	27.	(a)	28.	(b)	29.	(c)	30.	(c)

For *fcc*, $Z_1 = 4$; $V_1 = a^3 = (3.5 \times 10^{-8})^3$

For *bcc*, $Z_2 = 2$; $V_2 = a^3 = (3.0 \times 10^{-8})^3$

$$\frac{d_{fcc}}{d_{bcc}} = \frac{4 \times (3 \times 10^{-8})^3}{2 \times (3.5 \times 10^{-8})^3} = 1.259$$

8. **(c) :** Solvent molecules flow from low concentration solution to high concentration solution.

9. **(d)**

10. **(a,c) :** Contribution of $M = \frac{1}{2} \times 2 = 1$

Contribution of $X = \frac{1}{4} \times 4 = 1$

$\therefore$ Empirical formula = MX

Distance between M and X, *i.e.*, bond length of M–X bond

$$= \sqrt{\frac{a^2}{4} + \frac{a^2}{2}} = \sqrt{\frac{3}{4}}a = \frac{\sqrt{3}}{2}a = 0.866\ a$$

Both cation, M and anion, X have same coordination number *i.e.*, 8.

Assuming, anions are in contact, the ratio of ionic radii of cation M to anion X is 0.732, the minimum radius ratio for a cubical void.

11. **(d):** $d = \frac{ZM}{N_A a^3}$ [$\because$ For *fcc*, $Z = 4$]

$$= \frac{4 \times 63.55}{6.023 \times 10^{23} \times x^3 \times 10^{-24}} = \frac{42.20}{x^3} \times 10 = \frac{422}{x^3}$$

12. **(a) :** The reaction when KI is added in HgI_2

$HgI_2 + 2KI \longrightarrow K_2HgI_4 \rightleftharpoons 2K^+ + HgI_4^{2-}$

Since, number of ions decreased, so freezing point increases.

13. **(a) :** $n = 4$, a = 0.574 mm

Shortest separation of two potassium nuclei = $d = 2r$

$$2r = \frac{a}{\sqrt{2}} = \frac{0.574}{1.414}\text{ mm} = 0.4059\text{ mm}$$

14. **(d):** Number of atoms of A per unit cell = $8 \times \frac{1}{8} = 1$

Number of atoms of B per unit cell = $(6-1) \times \frac{1}{2} = \frac{5}{2}$

(one B atom is missing)

Thus, formula is $A_1B_{5/2} = A_2B_5$.

15. **(d):** All the statements are correct

16. **(b):** For a body centred cubic unit cell (*bcc*)

$$\text{Radius } (r) = \frac{a \times \sqrt{3}}{4} = \frac{(4.29\ \text{Å}) \times 1.732}{4} = 1.86\ \text{Å}$$

Length of the body diagonal = $4r = 4 \times 1.86 = 7.44$ A

17. **(a) :** In the crystallization, some Ag^+ ions will get replaced by as many as half of Cd^{2+} ions so as to maintain electrical neutrality. Thus, the cation vacancies will be the same as the number of Cd^{2+} ions incorporated.

18. **(c) :** Given that, $a = 4.077 \times 10^{-8}$ cm

Crystal density = 10.5 gm cm^{-3}

for *fcc*, $Z = 4$

$\because$ Crystal density $= \frac{Z \times M_w}{V \times N_A}$

$$10.5 = \frac{4 \times M_w}{(4.077 \times 10^{-8})^3 \times 6.023 \times 10^{23}}$$

$$M_w = \frac{10.5 \times 67.76 \times 10^{-24} \times 6.023 \times 10^{23}}{4} = 107.14$$

19. **(a) :** Van't Hoff factor (i)

$$= \frac{\text{No. of particles after association or dissociation}}{\text{No. of particles before association or dissociation}}$$

For $MX_2 \rightleftharpoons M^+ + 2X^-$

$t = 0$	1	0	0
at eq.	$1 - \alpha$	α	2α

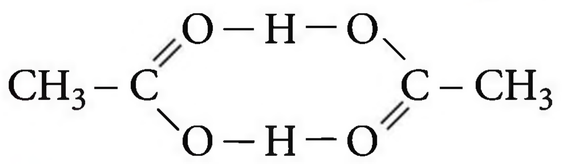
Total no. particles = $1 - \alpha + \alpha + 2\alpha = 1 + 2\alpha$

$\therefore$ $i = \frac{1 + 2\alpha}{1} = 2.$

$\therefore$ $\alpha = 0.50$ or 50%

20. **(a) :** Since MgO have NaCl (rock salt) structure, and in NaCl the coordination number of ions are 6 and 6 respectively. Thus, in MgO, O^{2-} also have coordination number 6.

21. **(d):** Acetic acid contain carboxylic group –COOH which can form H-bonding so acetic acid dimerises.



22. **(d):** Osmotic pressure is directly proportional to the number of particles in the solution. KCl will dissociate

MONTHLY TEST DRIVE CLASS XII ANSWER KEY

1.	(a)	**2.**	(b)	**3.**	(c)	**4.**	(a)	**5.**	(c)
6.	(b)	**7.**	(d)	**8.**	(b)	**9.**	(c)	**10.**	(d)
11.	(b)	**12.**	(b)	**13.**	(a)	**14.**	(d)	**15.**	(c)
16.	(a)	**17.**	(c)	**18.**	(c)	**19.**	(a)	**20.**	(a, b,c)
21.	(a,c)	**22.**	(b,d)	**23.**	(a,b,d)	**24.**	(3)	**25.**	(5)
26.	(4)	**27.**	(d)	**28.**	(c)	**29.**	(b)	**30.**	(c)

completely in the solution, while CH_3COOH and sucrose are weak electrolyte. Hence correct order will be : KCl > CH_3COOH > Sucrose

23. (b): Number of defects per mole of NaCl

$$= 6.02 \times 10^{23} \text{ formula units}$$

$$= \frac{1 \times 6.02 \times 10^{23}}{10^{15}} = 6.02 \times 10^{8}$$

24. (d)

25. (b): Mixture of pure CS_2 and CH_3COCH_3 shows positive deviation from Raoult's law. For such solution, $\Delta V_{mixing} > 0$ and $\Delta H_{mixing} > 0$.

26. (6): It is evident from that *B* occupies octahedral voids and thus, coordination number is six.

27. (291.4) : Given $P_1 = 19$ mm Hg, $P_2 = 760$ mm Hg; $\Delta H_{vap} = 40670$ J/mol

Applying Clausius-Clapeyron's equation

$$\log \frac{P_2}{P_1} = \frac{\Delta H_{vap}}{2.303 \times R}\left(\frac{T_2 - T_1}{T_1 T_2}\right)$$

or $$\log \frac{760}{19} = \frac{40670}{2.303 \times 8.3}\left(\frac{373 - T_1}{T_1 \times 373}\right)$$

on solving, we get $T_1 = 291.4$ K

28. (62) : Volume of one atom of $Ar = \frac{4}{3}\pi r^3$

Also, number of atoms in 1.65 g per mL

$$= \frac{1.65}{40} \times 6.023 \times 10^{23}$$

∴ Total volume of all the atoms of Ar in solid state

$$= \frac{4}{3}\pi r^3 \times \frac{1.65}{40} \times 6.023 \times 10^{23}$$

$$= \frac{4}{3} \times \frac{22}{7} \times (1.54 \times 10^{-8})^3 \times \frac{1.65}{40} \times 6.023 \times 10^{23}$$

$$= 0.380 \text{ cm}^3$$

Volume of solid Ar = 1 cm^3

$$\therefore \quad \% \text{ empty space} = \frac{1 - 0.38}{1} \times 100 = 62\%$$

29. (0.74) : Given $P_A = 750$ mm Hg

∴ 373 K is boiling point of water.

Thus, $P_A^\circ = 760$ mm Hg

$$m = \left(\frac{P^\circ - P}{P}\right) \times \frac{1000}{M_{solvent}}$$

$$\Rightarrow \frac{10}{750} \times \frac{1000}{18} \Rightarrow 0.74 \text{ m}$$

30. (15) : Iron is 93% and O is 100%.

Let Fe^{+++} be x%, then $Fe^{++} = (93 - x)\%$

Balancing positive and negative charges *i.e.*,

Total charge on Fe^{++} and Fe^{+++} ion = Total charge on O^{2-} ion.

$$2(93 - x) + 3x = 2 \times 100$$

$$\therefore \quad x = 14$$

$$\therefore \quad \% \text{ of } Fe^{+++} = \frac{14}{93} \times 100 = 15.0\%$$

Researchers develop tool to aid in development, efficiency of hydrogen-powered cars

Fuel cell electric vehicles combine hydrogen in a tank with oxygen taken from the air to produce the electricity needed to run. They don't need to be plugged in to charge and have the added benefit of producing water vapor as a byproduct. Those, plus other factors, have made them an intriguing option in the green and renewable energy transportation areas.

A key goal to making the vehicles viable is to find an effective catalyst in the fuel cell that can "burn" the hydrogen with oxygen under controlled conditions needed for safe travel. At the same time, researchers are looking for a catalyst that can do this at near room temperature, with high efficiency and a long lifetime in acidic solution. Platinum metal is commonly used, but predicting the reactions and best materials to use for scaling up or different conditions has been a challenge to date.

Researchers developed models for metal nanostructures and oxygen, water and metal interactions that exceed the accuracy of current quantum methods by more than 10 times. The models also enable the inclusion of the solvent and dynamics and reveal quantitative correlations between oxygen accessibility to the surface and catalytic activity in the oxygen reduction reaction." The interaction between oxygen molecules as they encounter different barriers by molecular layers of water on the platinum surface. These interactions make the difference between a slow or fast follow-on reaction and need to be controlled for the process to work efficiently. These reactions happen quite fast - the conversion into water takes about a millisecond per square nanometer to complete - and happen on a tiny catalyst surface.

The computational and data-intensive methods described can be used to create designer-nanostructures that would max out the catalytic efficiency, as well as possible surface modifications to further optimize the cost-benefit ratio of fuel cells.

MONTHLY TEST DRIVE

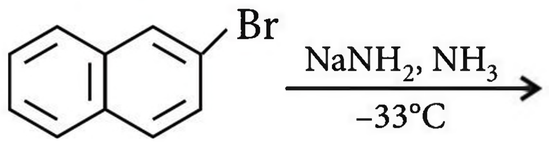
This specially designed column enables students to self analyse their extent of understanding of specified chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

Total Marks : 120 **Haloalkanes and Haloarenes | Alcohols, Phenols and Ethers** **Time Taken : 60 Min.**

NEET

Only One Option Correct Type

1. How many isomeric naphthylamines are expected in the following reaction?



(a) Two (b) One (c) Four (d) Three

2. $Y \xleftarrow[CH_3ONa]{CH_3OH} H_2C\!-\!CHCH_3 \xrightarrow[H^+]{CH_3OH} X$ (O bridges the epoxide)

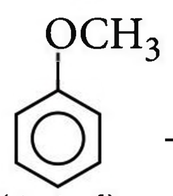
Here '*X*' and '*Y*' are respectively

(a) $CH_2(OCH_3)-CH(OH)-CH_3$ and $HOCH_2-CH(OCH_3)-CH_3$

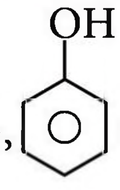
(b) $HOCH_2-CH(OCH_3)-CH_3$ and $CH_2(OCH_3)-CH(OH)-CH_3$

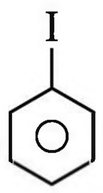
(c) $CH_2(OCH_3)-CH(OH)-CH_3$ in both cases

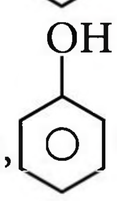
(d) $HOCH_2-CH(OCH_3)-CH_3$ in both cases.

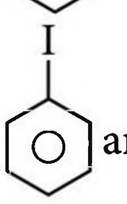
3. In the reaction,  (Anisol) $\xrightarrow[\text{reflux}]{HI}$

the mechanism followed and the major products are respectively

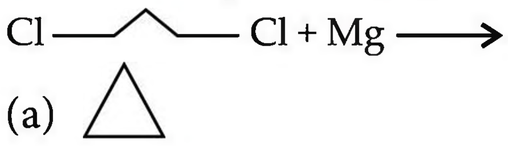
(a) S_N1,  and CH_3I

(b) S_N2,  and CH_3OH

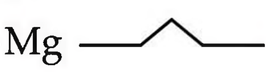
(c) S_N2,  and CH_3I

(d) S_N1,  and CH_3OH

4. What is the product [*A*] in the following reaction?

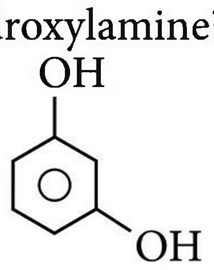


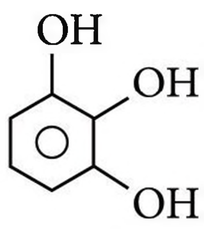
(a)

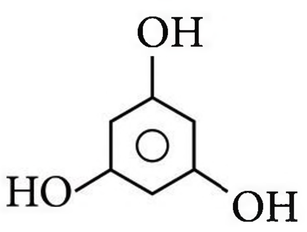
(b) Cl–Mg  Mg–Cl

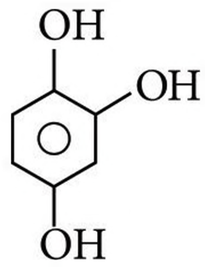
(c) Both (a) and (b) (d) None of these

5. Which of the following compounds can react with hydroxylamine?

(a) 

(b) 

(c) 

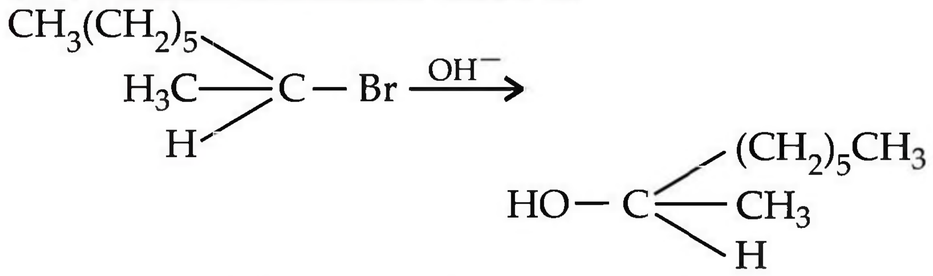
(d) 

Quotable Quote

"What we know is a drop, what we don't know is an ocean."

Isaac Newton

6. The reaction described below is



(a) S_E1 (b) S_N2 (c) S_N1 (d) S_E2

7. Dehydration of an alcohol in the presence of sulphuric acid gives alkene.

$$CH_3CH_2OH \xrightarrow{H_2SO_4} CH_2 = CH_2 + H_2O$$

Here sulphuric acid acts as

(a) an acid (b) a base
(c) a catalyst (d) all of these.

8. Predict the major products, P_1 and P_2 in the following two reactions.

(i) $Me_2CHBr \xrightarrow{CH_3COO^-} P_1$

(ii) $CH_3(CH_2)_{15}CH_2CH_2Br \xrightarrow{(CH_3)_3CO^-} P_2$

(a) P_1 is $Me_2CHOCOCH_3$, P_2 is $CH_3(CH_2)_{15}CH_2CH_2OCMe_3$

(b) P_1 is $Me_2CHOCOCH_3$, P_2 is $CH_3(CH_2)_{15}CH = CH_2$

(c) P_1 is $CH_3CH = CH_2$, P_2 is $CH_3(CH_2)_{15}CH_2CH_2OCMe_3$

(d) P_1 is $CH_3CH = CH_2$, P_2 is $CH_3(CH_2)_{15}CH = CH_2$

9. Which of the following order is not correct?

(a) $MeBr > Me_2CHBr > Me_3CBr > Et_3CBr(S_N2)$

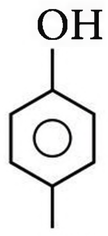
(b) $Me_3CBr > Me_2CHBr > Me_2CHCH_2Br > MeCH_2CH_2CH_2Br(E_2)$

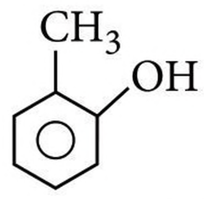
(c) $PhCH_2Br > PhCHBrMe > PhCBrMe_2 > PhCBrMePh(S_N1)$

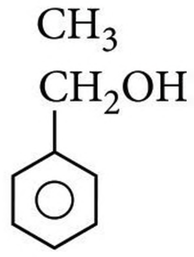
(d) $MeI > MeBr > MeCl > MeF\ (S_N2)$

10. Which of the following will decolourise $KMnO_4/H^+$ and change the orange colour of $K_2Cr_2O_7/H^+$ to green?

(a) 

(b) 

(c) 

(d) 

11. Bottles containing C_6H_5I and $C_6H_5CH_2I$ lost their original labels. They were labelled *A* and *B* for testing. *A* and *B* were separately taken in test tubes and boiled with NaOH solution. The end solution in each tube was made acidic with dilute HNO_3 and some $AgNO_3$ solution was added. Solution *B* gave yellow precipitate. Which one of the following statements is true for the experiment?

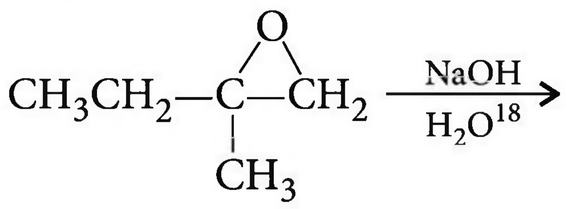
(a) Addition of HNO_3 was unnecessary

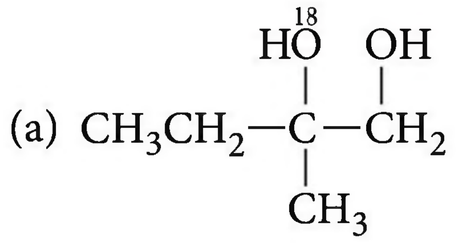
(b) *A* was C_6H_5I

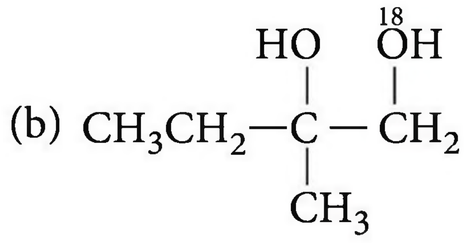
(c) *A* was $C_6H_5CH_2I$

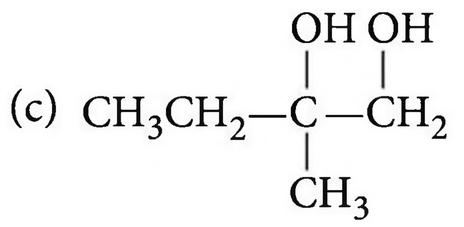
(d) *B* was C_6H_5I

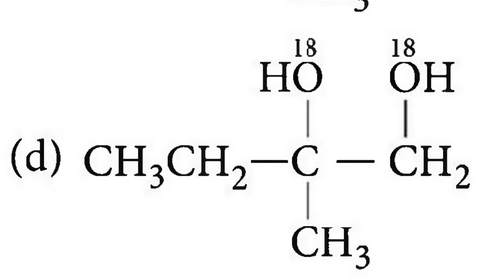
12. Major product of the given reaction is



(a) 

(b) 

(c) 

(d) 

Assertion & Reason Type

Directions : In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as :

(a) If both assertion and reason are true and reason is the correct explanation of assertion.

(b) If both assertion and reason are true but reason is not the correct explanation of assertion.

(c) If assertion is true but reason is false.

(d) If both assertion and reason are false.

13. **Assertion :** The bond angle in alcohols is slightly less than the normal tetrahedral bond angle.
Reason : Lone pair - lone pair repulsion decrease the bond angle.

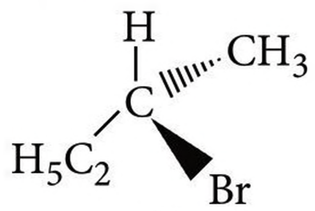
14. **Assertion :** S_N2 reaction proceeds with racemisation while S_N1 reaction proceeds with complete stereochemical inversion.
Reason : S_N2 is two steps reaction while S_N1 is one step reaction.

15. **Assertion :** With HI at 373 K, methyl *tert*-butyl ether gives *tert*-butyl iodide and methanol.
Reason : The reaction occurs by S_N2 mechanism.

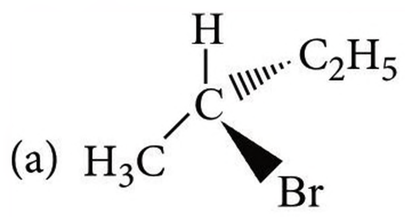
JEE MAIN / JEE ADVANCED

Only One Option Correct Type

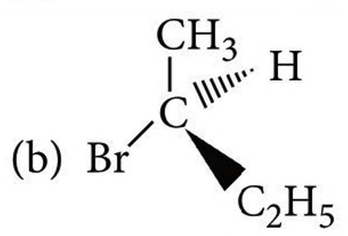
16. Which of the following structures is enantiomeric with the molecule (I) given below :



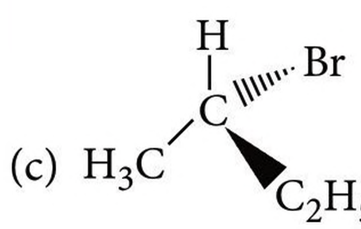
(I)



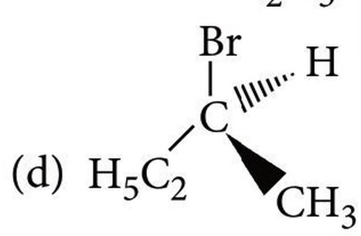
(a)



(b)



(c)

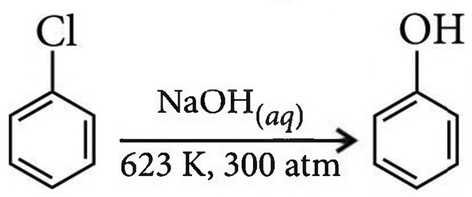


(d)

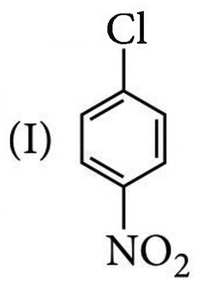
17. The major reason that phenol is a better Bronsted acid than cyclohexanol is _____.
(a) it is a better proton donor
(b) the cyclohexyl group is an electron donating group by induction, which destabilizes the anion formed in the reaction
(c) phenol is able to stabilize the anion formed in the reaction by resonance
(d) the phenyl group is an electron withdrawing group by induction, which stabilizes the anion formed in the reaction

18. Which set of reagents will produce CCl_2F_2 ?
(a) $C + F_2 + Cl_2 \longrightarrow$ (b) $CH_3Cl + F_2 \longrightarrow$
(c) $CCl_4 + SbF_3 \xrightarrow{SbCl_5}$ (d) $CCl_4 + F_2 \longrightarrow$

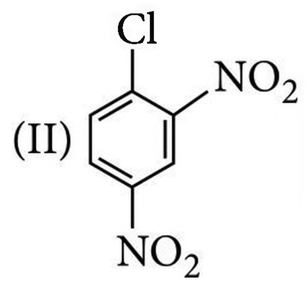
19. Chlorobenzene can be converted into phenol by heating in aqueous sodium hydroxide solution at a temperature of 623 K and a pressure of 300 atm.



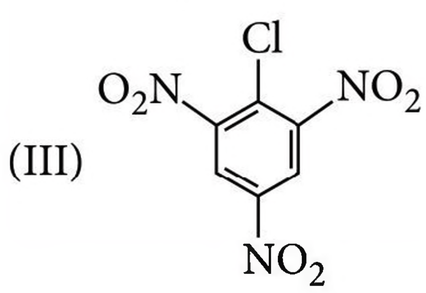
What will be the order of reactivity of following compounds towards the above substitution reaction?



(I)



(II)



(III)

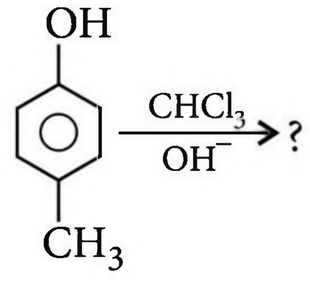
(a) (III) > (II) > (I) (b) (II) > (III) > (I)
(c) (I) > (II) > (III) (d) (I) > (III) > (II)

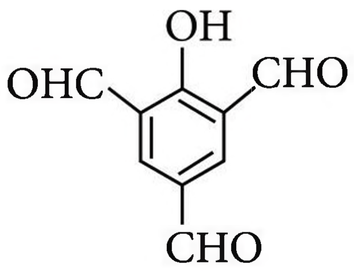
More than One Options Correct Type

20. Which of the following cannot be prepared by the typical Williamson reaction?
(a) R_3COCR_3
(b) ArOAr
(c) $RCH = CHOCH = CHR'$
(d) $C_6H_5CH_2OC_2H_5$

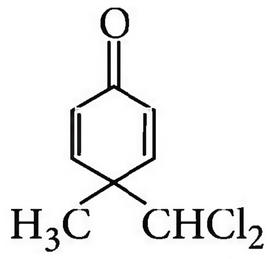
21. Ethylene chloride and ethylidene chloride are isomers. Identify the correct statements.
(a) Both the compounds form same product on treatment with alcoholic KOH.
(b) Both the compounds form same product on treatment with aq. NaOH.
(c) Both the compounds form same product on reduction
(d) Both the compounds are optically active.

22. In the following reaction, the product(s) formed iare

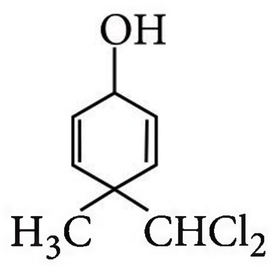




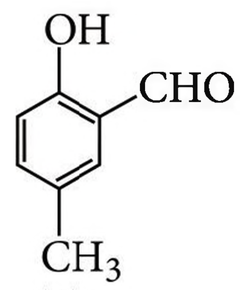
(*P*)



(*Q*)



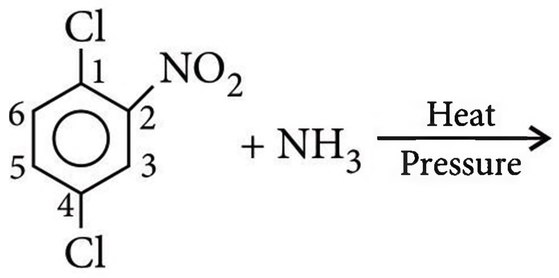
(*R*)



(*S*)

(a) *P* (major) (b) *Q* (minor)
(c) *R* (minor) (d) *S* (major)

23. Which of the following statements are false regarding the given reaction?



(a) No reaction is possible because —Cl is present on benzene ring.

(b) A nucleophilic substitution will take place in which both —Cl will be replaced by two $-NH_2$ groups.

(c) A nucleophilic substitution will take place in which only —Cl attached on C_1 will be replaced by $-NH_2$.

(d) A nucleophilic substitution will take place in which only —Cl attached on C_4 will be replaced by $-NH_2$.

Integer / Numerical Value Type

24. Acetylation of a polyhydric alcohol increases its molecular mass by 126 units. The number of 'OH' groups in the molecule is

25. A hydrocarbon (*X*) having molecular weight 70 gives a single monochloride but three dichlorides on chlorination in the presence of ultraviolet light. The number of C-atoms in hydrocarbon (*X*) are

26. Number of isomers of $C_5H_{11}OH$ which are primary alcohols is

Comprehension Type

An alkyl halide with α-hydrogen atoms when reacted with a base or a nucleophile has two competing routes substitution (S_N1 and S_N2) and elimination. Which route will be taken up depends upon the nature of alkyl halide, strength and size of base/nucleophile and reaction conditions.

27. Consider the following reactions of primary alkyl halides.

I. $CH_3CH_2CH_2CH_2Br + CH_3O^- \xrightarrow{CH_3OH}$

II. $CH_3\underset{\displaystyle CH_3}{\underset{|}{C}}HCH_2Br + CH_3O^- \xrightarrow{CH_3OH}$

III. $CH_3CH_2CH_2CH_2Br + (CH_3)_3CO^- \xrightarrow{(CH_3)_3COH}$

Major products of these reactions are respectively

(a) $CH_3CH_2CH=CH_2$;
$CH_3\underset{\displaystyle CH_3}{\underset{|}{C}}=CH_2$; $CH_3CH_2CH=CH_2$

(b) $CH_3CH=CHCH_3$;
$CH_3\underset{\displaystyle CH_3}{\underset{|}{C}}=CH_2$; $CH_3CH=CHCH_3$

(c) $CH_3CH_2CH_2CH_2OCH_3$; $CH_3\underset{\displaystyle CH_3}{\underset{|}{C}}HOCH_3$;
$CH_3CH_2CH_2CH_2OC(CH_3)_3$

(d) $CH_3CH_2CH_2CH_2OCH_3$; $CH_3\underset{\displaystyle CH_3}{\underset{|}{C}}=CH_2$;
$CH_3CH_2CH=CH_2$

28. Consider the following S_N2/E2 reactions on 2-chloropropane.

$$B \xleftarrow[CH_3CH_2OH]{CH_3CH_2O^-} (CH_3)_2CHCl \xrightarrow[CH_3COOH]{CH_3\overset{\displaystyle O}{\overset{\|}{C}}O^-} A$$

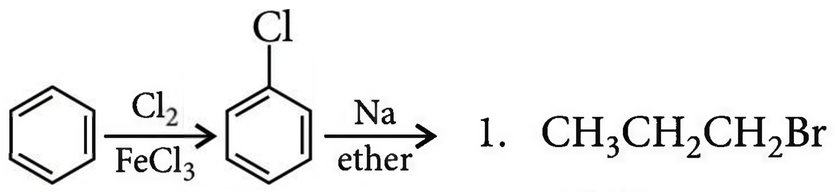
Select the correct alternate(s).

(a) Major products *A* and *B* are the substitution products.
(b) Major products *A* and *B* are the elimination products.
(c) Major product *A* is the substitution product and major product *B* is the elimination product.
(d) Major product *A* is the elimination product and major product *B* is the substitution product.

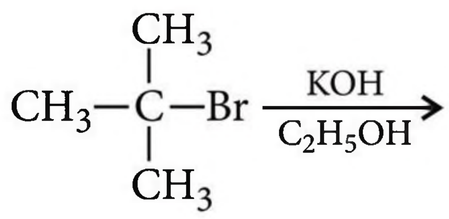
Matrix Match Type

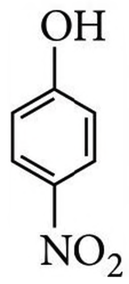
29. Match the List I with List II and select the correct answer using the code given below the lists :

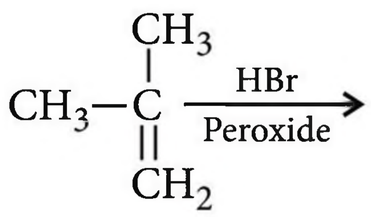
List I **List II**

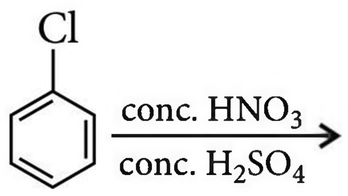
P. 

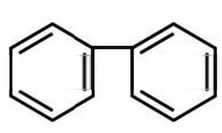
1. $CH_3CH_2CH_2Br$

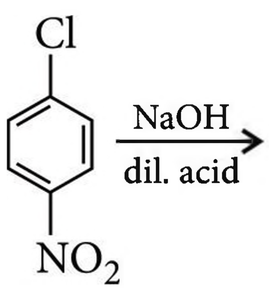
Q. 

2. 

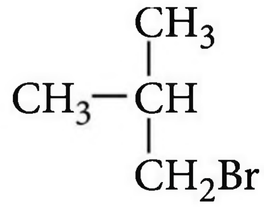


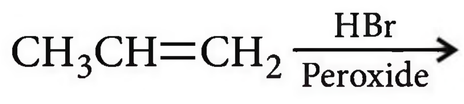
R. 

3. 



S. 

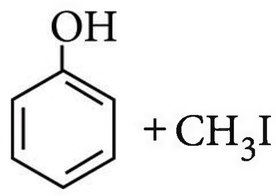
4. 

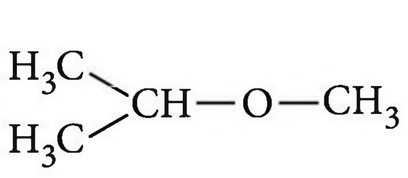
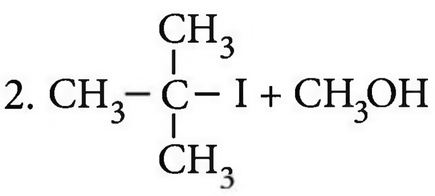


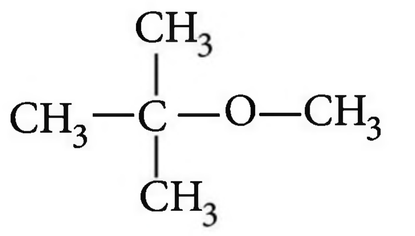
	P	Q	R	S
(a)	4	2	1	3
(b)	3	4	2	1
(c)	2	1	3	4
(d)	1	3	4	2

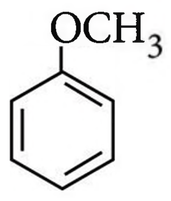
30. Match the starting materials given in List I with the products formed by these with HI given in List II and select the correct answer using the codes given below the lists :

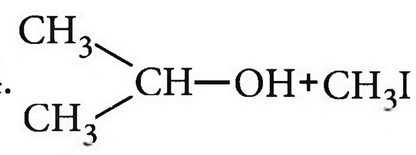
List I **List II**

P.
1. 

Q. 
2. 

R. 
3. $CH_3-OH + CH_3-I$

S. 

4. 

	P	Q	R	S
(a)	1	2	3	4
(b)	4	3	2	1
(c)	3	4	2	1
(d)	3	4	1	2

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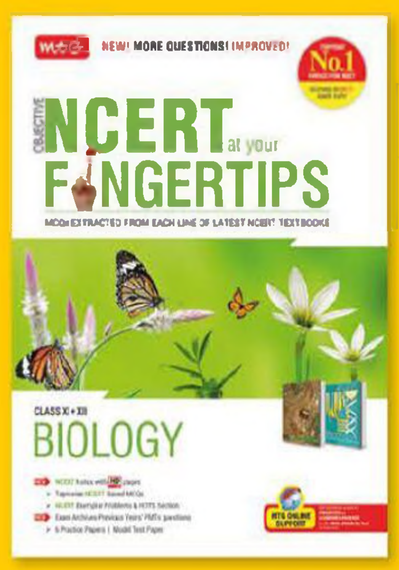

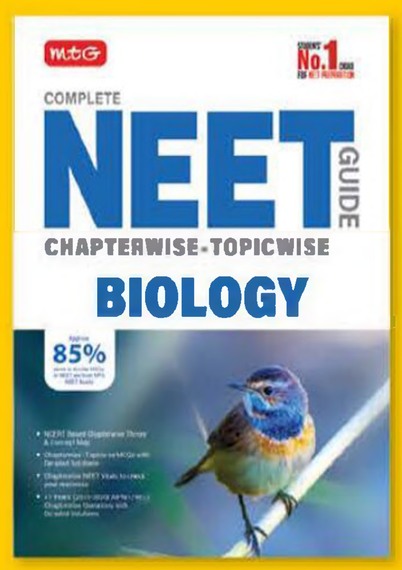

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